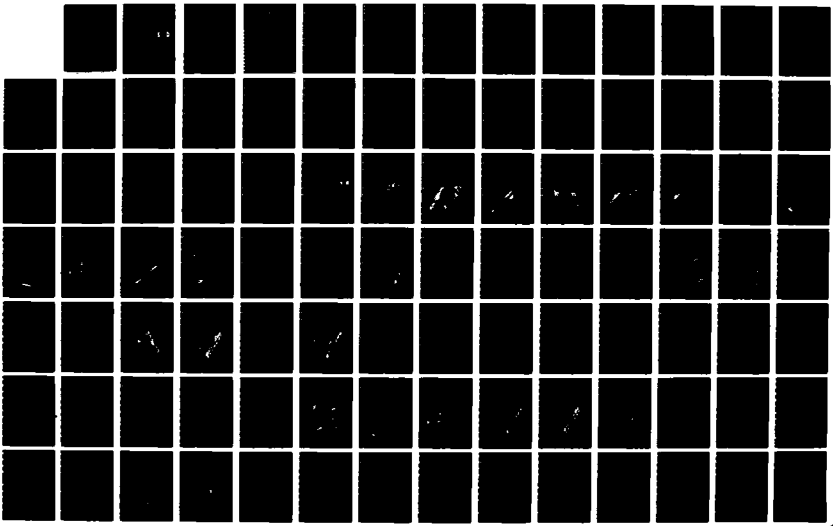
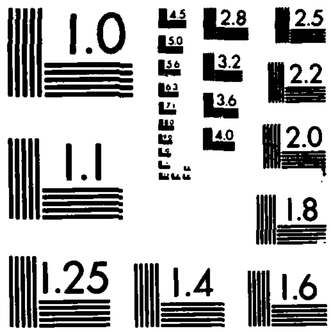
AD-A183 994 LIGHTWEIGHT TOWED HOWITZER DEMONSTRATOR PHASE 1 AND PARTIAL PHASE 2 VOLUM (U) FMC CORP MINNEAPOLIS MINN NORTHERN ORDNANCE DIV R RATHE ET AL APR 87 1/2

UNCLASSIFIED FMC-E-3041-VOL-D3-PT-2 DAAA21-86-C-0047 F/G 19/6 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Lightweight Towed Howitzer Demonstrator

Final Report

Volume D3 - Part II

Structural Analysis of System

April 1987

Contract Number DAAA21-86-C-0047

FMC CORPORATION
Northern Ordnance Division
4800 East River Road
Minneapolis, Minnesota 55421

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None

19. KEY WORDS (Continue on reverse side if necessary and identify by block number) 155mm towed gun howitzer, advanced weapons, composite cradle, composite hydraulic actuators, composite trails, field artillery weapon, firing stability analysis, howitzers, hydraulic control valves with force feedback, hydraulic joystick control of gun direction, hydraulic inertial rammer, hydraulic opening breech, hydraulic primer autoloader, ~~lightweight towed howitzer demonstrator (LTHD)~~, load out of battery howitzer, mortar howitzer, recoil energy recovery, recoil mechanism, ~~using~~ metal matrix composites, titanium muzzle brake, titanium platform, titanium spade, titanium walking beams, thermal stability, towing stability analysis, unconventional weapons, ~~and weight reduction of artillery~~.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The LTHD (Lightweight Towed Howitzer Demonstrator) was to be a 9,000 lb equivalent to the M198, transportable via Blackhawk helicopter, with reduced emplacement time using fewer personnel. The FMC design achieved weight reduction via a mortar-like configuration, composites structure, and hydraulic actuators. Recovery of power from the recoil system, in turn, facilitated crew reduction via hydraulic emplacement, four-way joystick tube lay, and power ramming. FMC completed Concept Development (Ph I) and two-thirds of Detailed Design (Ph II) prior to funds running out. Keywords:

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

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D3/200

CEL MEMO: JANUARY 26, 1987

FMC Central Engineering Laboratories
Santa Clara

Interoffice

To R. Rathe*

Date January 26, 1987

From C. R. Ortloff

cc L. Libhardt
J. Ries
L. Langerud
B. Anderson
B. Ziervick
E. Thuse
R. Kazares
A. Amberg

Subject **STRESS & STABILITY RESULTS FOR THE 22.5° GIMBAL ROTATION, 72° GUN ELEVATION SYSTEM MODEL LWHD UNDER PROOF IMPULSE LOADS**
*(figures 497-601 attached)

This stress report summarizes results of the system FE model load case (22.5°-72°) under the assumption of "hard soil" spade emplacement, free trail ends, and proof dynamic loads. Previously, reports have been forwarded for the 0°-0° case (CRO to L. Libhardt, 17 Dec 86), the 0°-72° case (CRO to L. Libhardt, 29 Dec 86) and the 22.5°-0° case (CRO to L. Libhardt, 8 Jan 87). This report completes the cycle of specified load cases for the system model with free trail ends and hard soil spade emplacement for dynamic impulse loading. To date, 601 computer hard copy figures have been delivered on system stress results.

SUMMARY

The present load case (22.5°-72°) appears to be the limiting case of the 4 cases thus far computed. In addition to previously observed gimbal failure zones (viz., the lower cradle attachment arms and shaft attachment zones on both upper and lower box beams), this load case indicates a plastic hinge failure of the gimbal upper arms also. This load case also confirms that plastic deformation occurs on the horizontal spade plate attached to the lower box beam of the platform. The details of stress pass results at times equal to 0.084, 0.129, 0.237 and 0.304 sec. are summarized below as are stability results. Stresses shown in the accompanying plots are von Mises equivalent stress values.

DETAILS OF STRESS PASS RUNS

Shown in figures 498 to 515 are dynamic displacement-time histories for Master Degree of Freedom nodes (MDOF) located on the platform. The locations of these nodes has been shown in earlier memos of this sequence. Peak displacement times are selected from these plots for use in stress pass calculations (Figures 521 to 595). A damping value of 0.2% is incorporated into the runs; in that actual system damping values (ALPHAD, BETAD) are unknown, the decay envelope of the oscillatory displacement behavior (exhibited in Figures 498-515) past c.310 ms may vary depending on the damping constant chosen. Use of the 0.2% damping value is conservative past c.310ms in that

system stability is not dependent on an energy dissipation mechanism (which may not exist). Below c.310 ms, where loads are applied, damping plays a minor role in stress and deflection levels; note that the stress pass times are all below c.310 ms and that this time range contains all the displacement peaks.

Reference to Figures 519 and 520 shows the MDOF node locations for Figures 516-518. Node 3009 is located on the cradle forward manifold. Figure 516 indicates about a 5 inch lateral (UX) deflection peak at c.750 ms as well as a 4 inch vertical excursion at about the same time. In that the torque vector can be decomposed into components in the (global) x,y,z directions (Figure 520), then moments exist (acting on the cradle arm) to twist the cradle about the x,y, and z axes simultaneously. The beam model used for the cradle is constructed to roughly match the bending and rotational stiffness of the 10-86 cradle design so that UX, UY deflections (Figures 516, 517) roughly model the dynamic deflection effect of both cradle and cable deflection. It appears that for the 22.5°, 72° load case then that the cradle experiences reasonably large UX and UY deflections. Depending on cradle and cable damping values, it is unclear if the duration of the cradle oscillations will interfere with reloading/reaiming procedures under "rapid fire" conditions. Later cradle designs with higher stiffness components will undoubtedly reduce these deflections and vibration levels.

Figures 521-539 summarize results for the stress pass at 0.304 sec. The conclusions are summarized below:

- o The upper gimbal arms (Figures 527, 528, 529, 532 and 537) contain stresses far in excess of the 80 ksi yield stress. A plastic hinge appears to develop and cause arm failure. The attachment zone of upper arms to gimbal (Figure 530) also shows zones of plastic failure.

- o Upper and lower platform tabs (Figures 533-534) appear to be adequately designed.

- o The lower gimbal arms contain tip zones (Figure 535) at the 80 ksi yield stress; although the actual gimbal mount zone has not been modeled exactly, nevertheless high stresses are encountered close to the mount points.

Figures 540-558 summarize stress results for the 0.084 sec. stress pass. The conclusions are summarized below.

- o The gimbal lower box beam shaft mount openings (upper and lower) exhibit stresses in excess of yield stress (Figures 540, 541, 542). The upper gimbal box beam shaft openings are in the elastic range.

- The platform (Figures 545-548) horizontal spade plate has zones between vertical reinforcing spacers that are in the plastic region. The moment (about the x-axis) and compressive force put on the lower platform box beam is substantial (considering that the spade horizontal plate is constrained by ground contact). This leads to stress concentration areas in the vicinity of the spade horizontal plate-lower box beam velded connection seams. As recommended in earlier memos, a possible fix to this recurring problem is to extend the triangular reinforcing tabs (front and rear) to the edge of the horizontal spade plate and/or use of several more of the extended reinforcing tabs in the open bays betveen the current tabs.

- Upper (Figure 549) and lower (Figure 550) platform to gimbal shaft mounting tabs appear to be adequately designed as stresses do not exceed 30 ksi.

- The lower gimbal arms (Figure 552) appear to have localized failure zones in the region of the cradle attachment points (here taken to be the central nodes denoted C_1, C_2). Although the actual connecting bearing region has not been modeled, nevertheless stresses are over 80 ksi in regions avay from the C_1, C_2 nodes. Based on St. Venant's principle, the vertical plate part of the I-Beam lower arms will need to be thickened to reduce stress levels near the C_1, C_2 nodes.

- The gimbal lower arm reinforcing plates(Figure 554) contain stresses in the plastic regime and need to be thickened to reduce stress to acceptable levels.

- The platform spade reinforcing spacers (Figures 555-557) appear adequate to absorb the side thrust loads as stresses shown are in the elastic range.

Figures 560-573 summarize stress results for the 0.237 sec. stress pass. The conclusions are summarized below.

- Again, this stress pass case indicates stresses over yield on the top gimbal arms (Figure 561).

- Stress on the lower gimbal box beam shaft opening (Figure 565) is at the yield value. This type of local failure has been observed for all the load cases and may be remedied by local reinforcement of the gimbal at all the box beam openings.

- Stresses on the platform horizontal spade plate exceed yield stress (Figure 567-569) in the plate bays between triangular reinforcing plates by as much as 40 ksi. The overstressed zones occur both ahead (Figure 569) and behind (Figure 567) the lover platform box beam.

Figures 575-595 summarize stress results for the 0.129 sec. stress pass. The conclusions are summarized below.

- o Local yielding again occurs on the platform vertical spade plate (Figures 575-577). Stresses in the outer panel bays exceed yield by about 4 ksi.

- o Stresses in the lower gimbal box beam shaft opening (or both upper and lower surfaces) exceed yield stress (Figures 578-580) by about 6 ksi.

- o Stresses in the lower gimbal arms (Figure 583) have localized stress zones over yield stress in the web area near the gimbal-cradle attachment zone. This type of failure has been previously observed for all other stress pass times.

The values given below summarize maximum stress results for the upper and lower shafts (connecting the gimbal to the platform). These results proceed from the printed output associated with each stress pass case together with interpretative descriptive material from the ANSYS 4.2B, V. I Manual, pp. 4.4.1-4.2.5. Reference to Figure 596 (lower shaft nodes), Figure 597 (lower shaft elements), Figure 598 (upper shaft nodes) and Figure 599 (upper shaft elements) is used with printout results to obtain the maximum shaft stress values.

- o The maximum upper shaft stress (for all times considered) is 37 ksi; the maximum lower shaft stress is 32.4 ksi. These stresses are the maximum of the outer fiber stresses.

- o The maximum force in the connecting rod (element 3262) between gimbal and platform is 13,000 lbf. This rod is necessary to prevent gimbal rotation within the platform frame caused by the Y components of torque on the gimbal. Recall that the STIF4 shafts have zero torsional stiffness so that the connecting rod is necessary for gimbal stability.

- o A survey of forces on connecting nodes from trails to platform (4 connecting nodes per trail) indicates a maximum force of about 4000 lbf. The forces are obtained by observing the stress in the beam elements of the trails joining connecting nodes on the platform and multiplying by the beam area.

SUMMARY OF THE FOUR LOAD CASES

Since all four load cases have now been computed for the system model, some general observations can be made with respect to gimbal and platform stress levels. The 22.5°-72° case contains all of the previously noted structural failure mechanisms; however, the details of prior load cases should be reviewed for stress levels.

- The upper gimbal arms appear to have stresses in the plastic reg_me in the time period $0<t<400$ ms (Figure 529, 537, 561) and most likely form a plastic hinge. No allowance has been made for the apparent yield stress increase under large load rates; i.e., the 80 ksi yield stress value is used for dynamic load conditions. Note that stresses can be as high as 2.65 X yield stress for the 0.304 sec. stress pass case.

- The lower gimbal arms likewise possess regions near the cradle mount zone that are over yield stress (Figures 540, 543, 552, 578). For many cases, stress levels are close to or exceed yield stress in the I-Beam web area as well as the triangular reinforcement plates connecting the arms to the gimbal box beams. Details of the maximum stress levels are obtainable from review of the totality of 0^o-0^o, 0^o-72^o, 22.5^o-0^o and 22.5^o-72^o load cases; this failure occurs for most of these load cases.

- The horizontal plate forming the top part of the spade is highly stressed. Since this plate lies on the ground and is constrained to move parallel to the ground, the lower platform box beam puts considerable moment and compressive force on the spade plate. The bay regions between vertical triangular reinforcement plates are in the plastic regime for most load cases. Several reinforcement ideas have been presented to strengthen this region.

- The upper and lower shaft opening zones on the gimbal, for both upper and lower box beams, are in the plastic regime. This result appears consistently in all the load cases and calls for local reinforcement of these gimbal areas.

o The upper and lower gimbal-to-platform shafts appear to be adequate for all load cases. Stresses between 20-50 ksi are encountered for these shafts for all load cases.

o The upper and lower platform to gimbal shaft mounting tabs appear to be adequate for all load cases as no stresses outside the elastic regime are encountered.

o The vertical platform and gimbal box beams can be reduced in thickness somewhat (about 30%) to raise their dynamic stress levels. The weight saved can be put to use in providing local reinforcement plates or thickness increases of elements elsewhere in the structure.

o Dynamic stability of the system exists for all load cases. The 22.5^o-72^o case appears to contain somewhat large horizontal and vertical amplitude displacements (about 4 inches) at low frequency (1-5 Hz) for the cradle. The high damping

characteristics of the composite slide tube and Kevlar cable may damp this motion out before the next firing event. More work needs to be done on the effect of material and geometric (structural) damping constants on system stability.

- The spade appears adequate to absorb loads for the "hard soil" model for all load cases computed.

CROrtloff

C. R. Ortloff

CRO/870126/01

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DOOOOGIBOMPLETE FOR 1001 DATA POINTS

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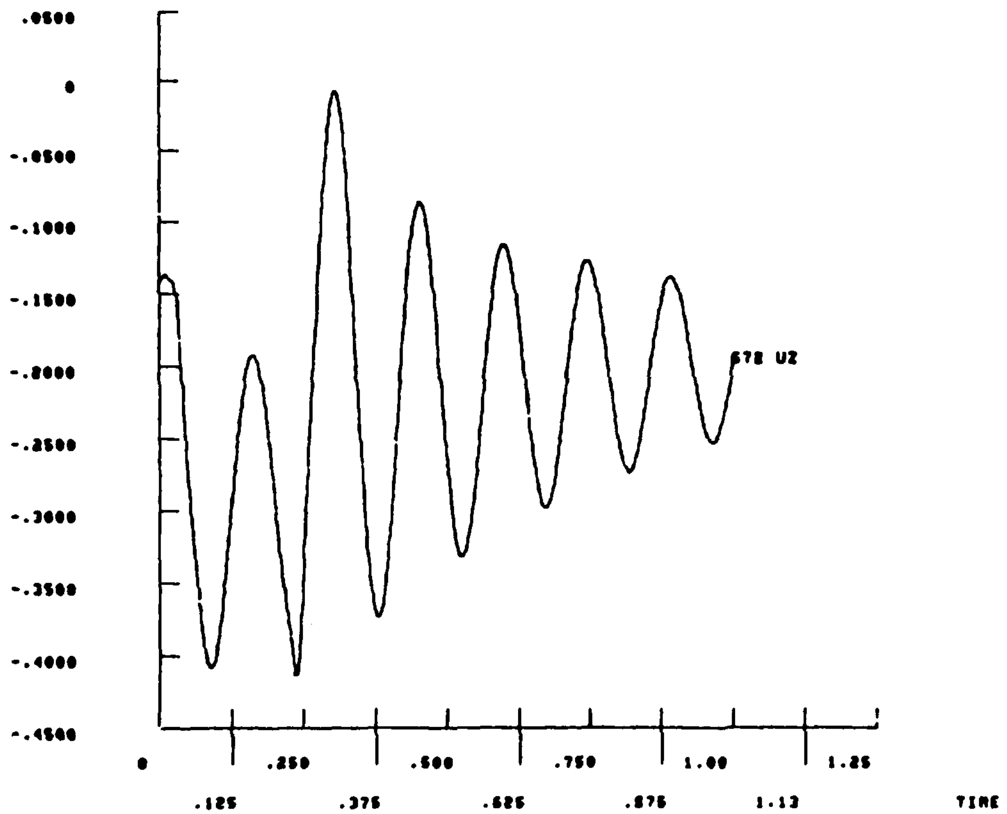

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LTHD-22.5,72 CASE,PROOF LOADS

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498

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PLOT DEFINITION

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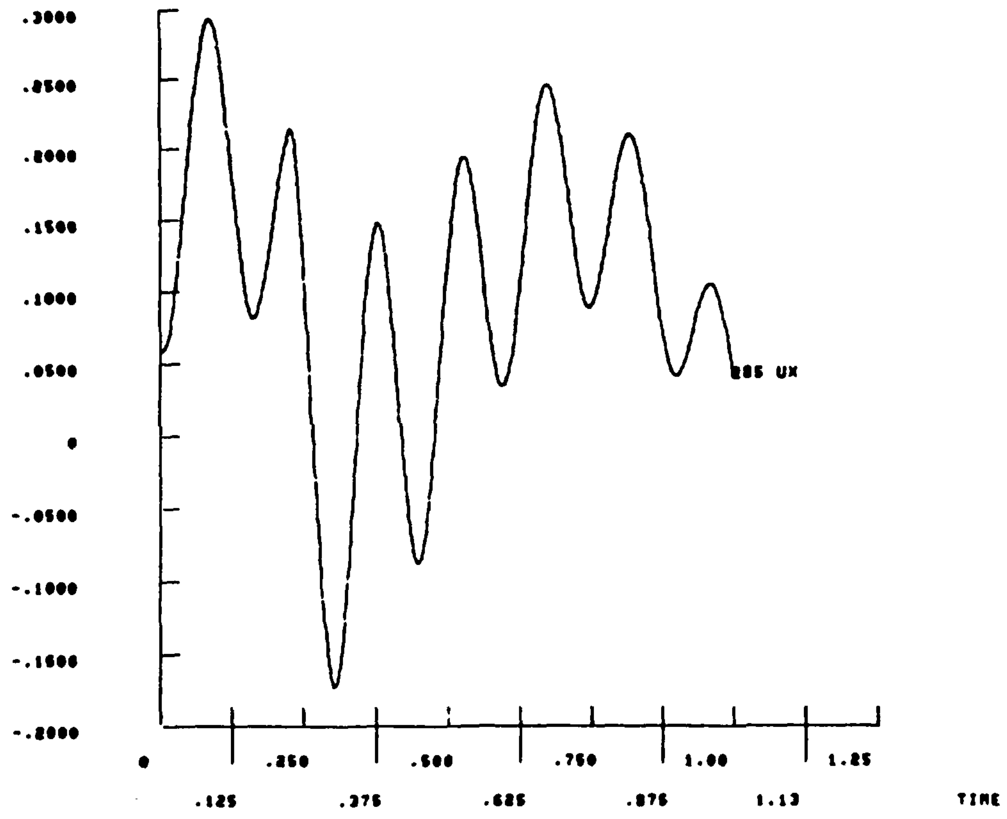

POST26

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LTHD-22.5,72 CASE,PROOF LOADS
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499

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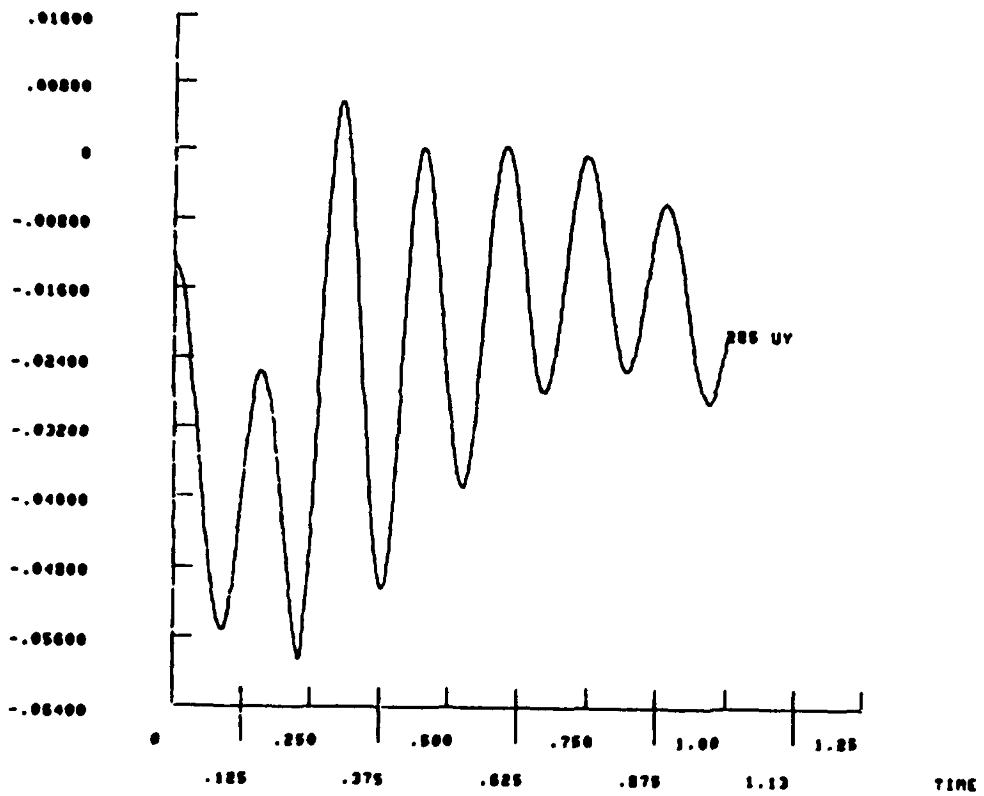

LTMD-22.5,72 CASE,PROOF LOADS
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POSTEG

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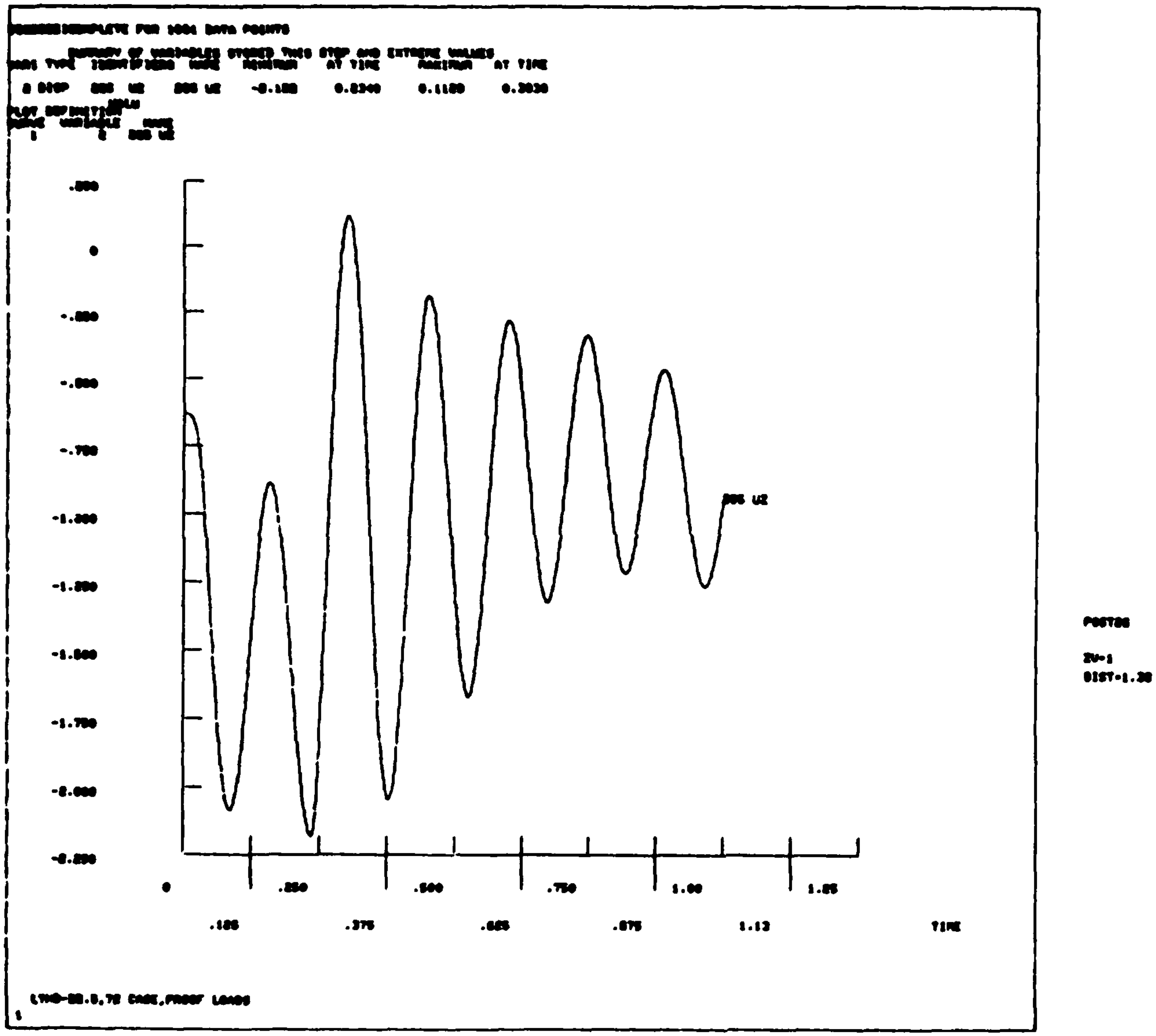
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CASE,PROOF LOADS

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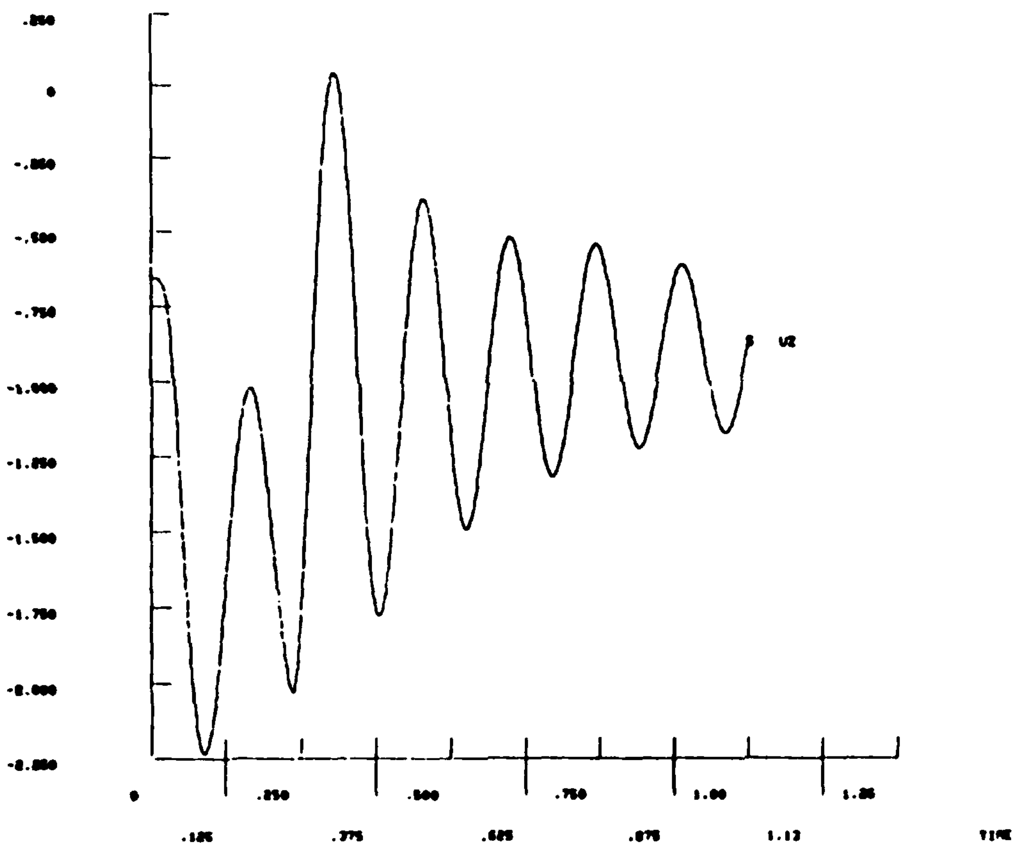

LTMB-88.5,78 CASE,PROOF LOADS

POSTDS

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DIST-1.30

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PLOT DEFINITION

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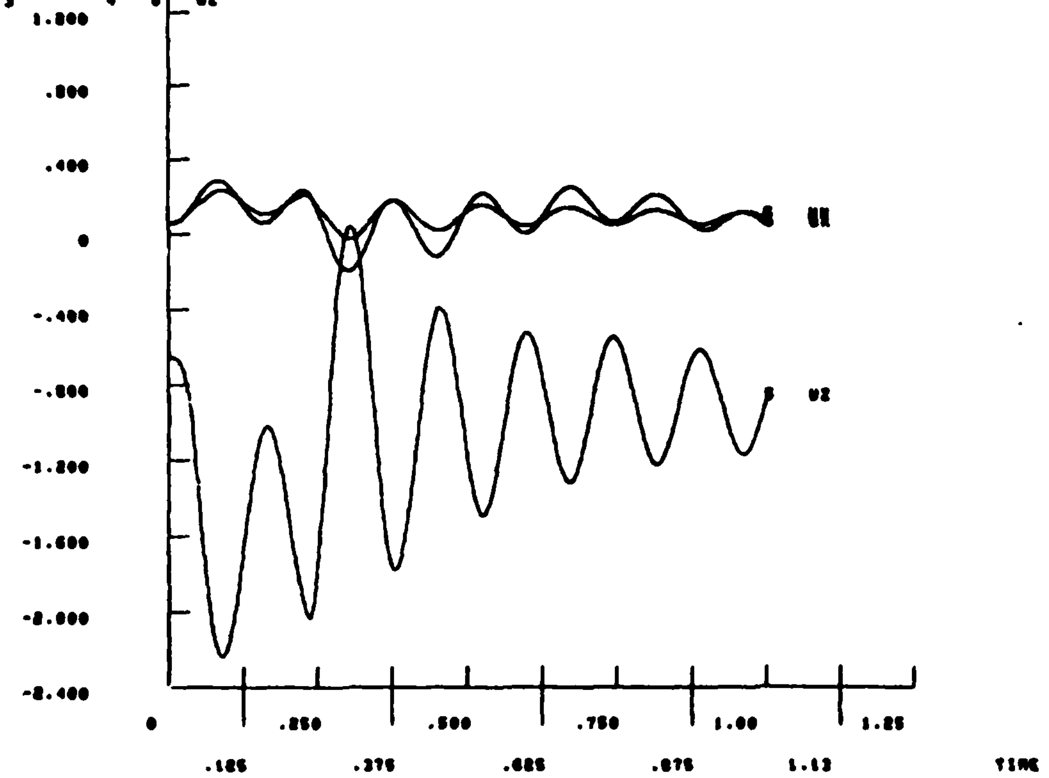
3	4	5	UZ



LTHD-22.5,72 CASE,PROOF LOADS

503

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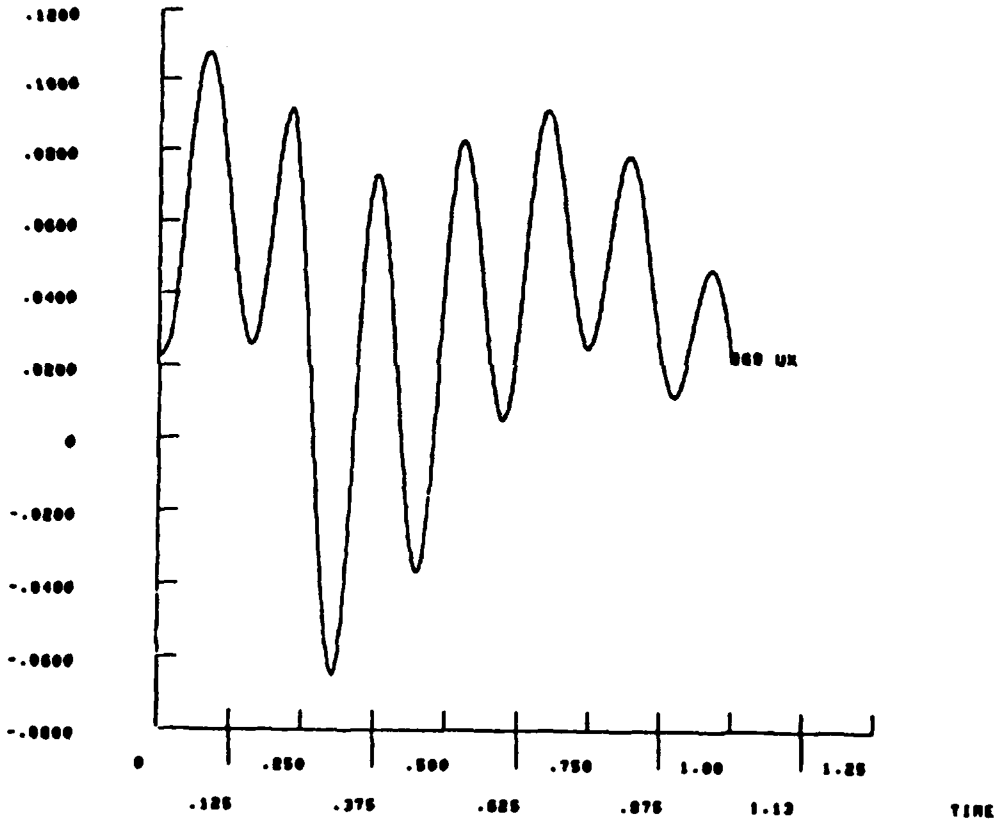

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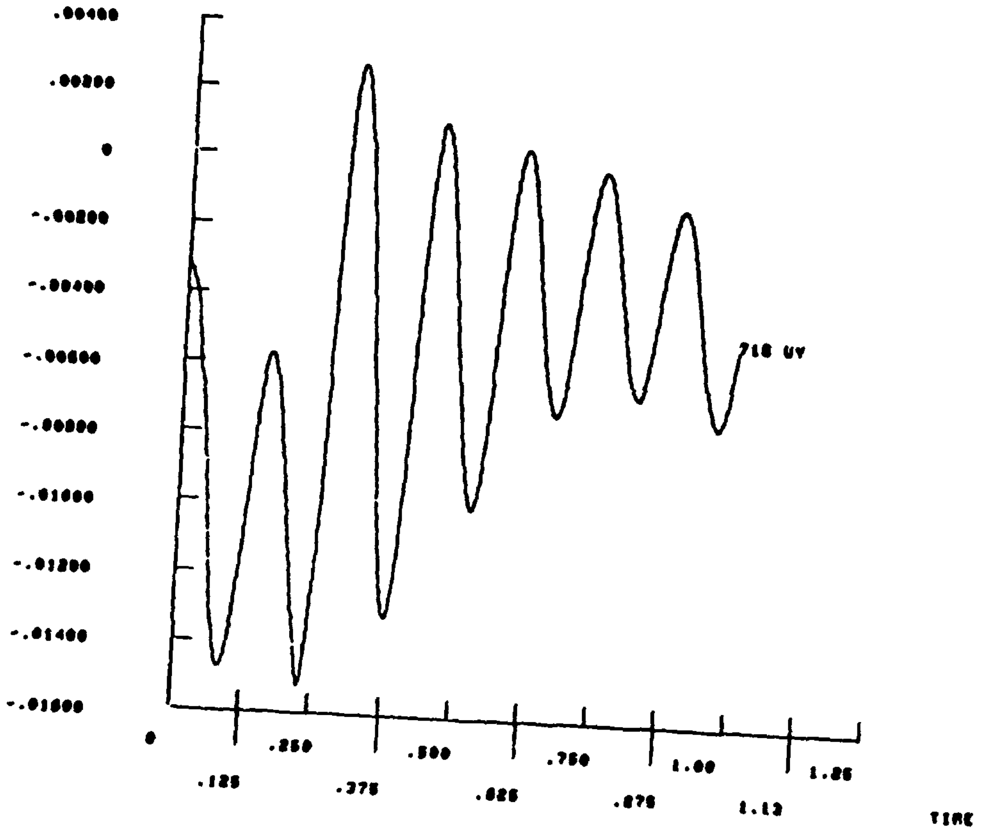

LTHD-22.5.72 CASE,PROOF LOADS

505 (15)

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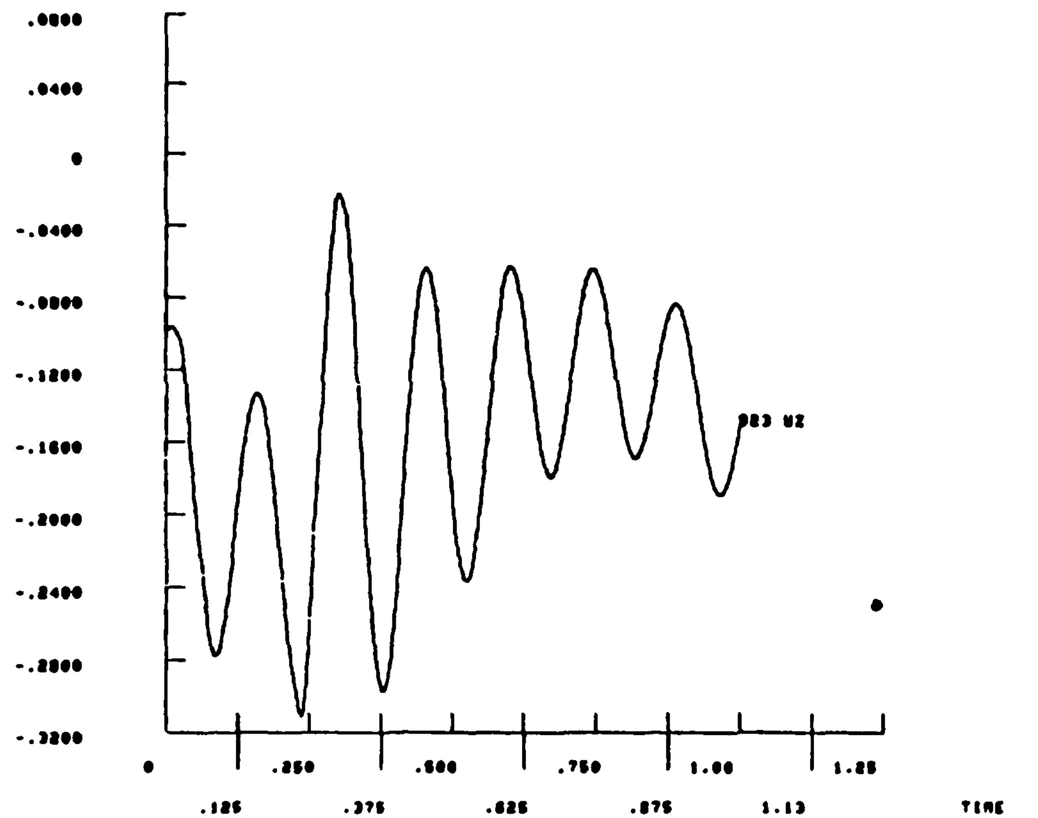

LTHD-22.5.72 CASE,PROOF LOADS

506

(16)

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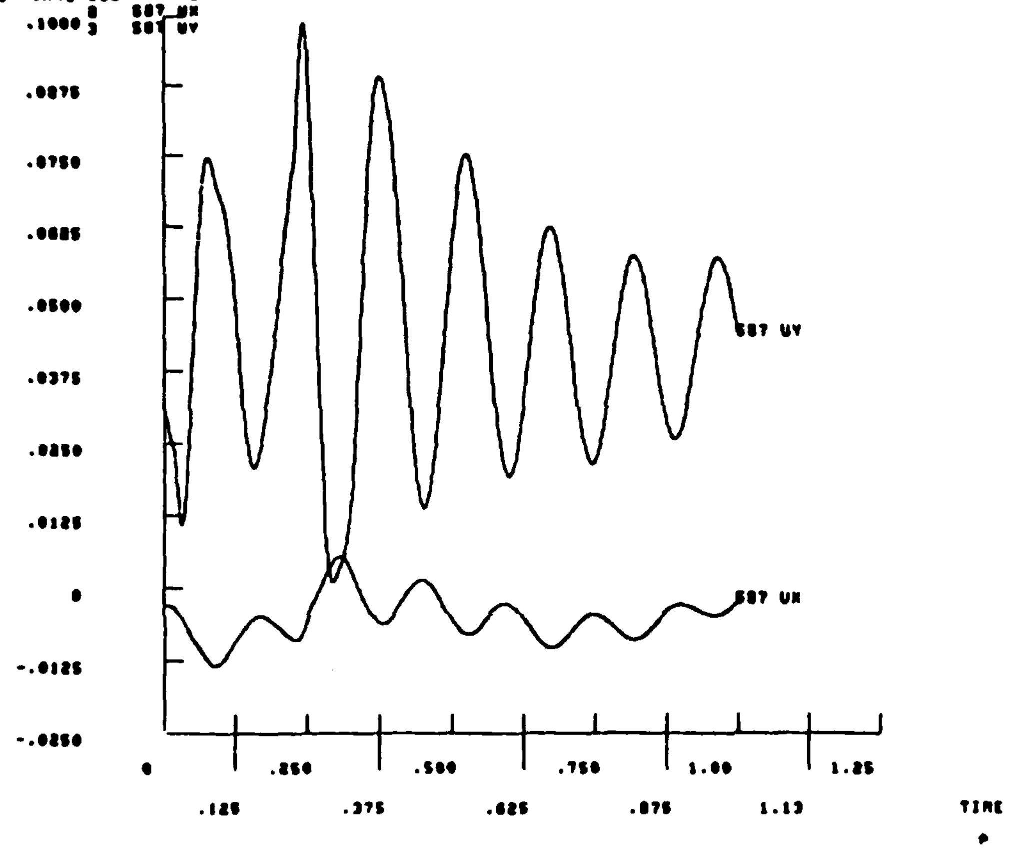

LTHD-22.5,75 CASE,PROOF LOADS

507

(17)

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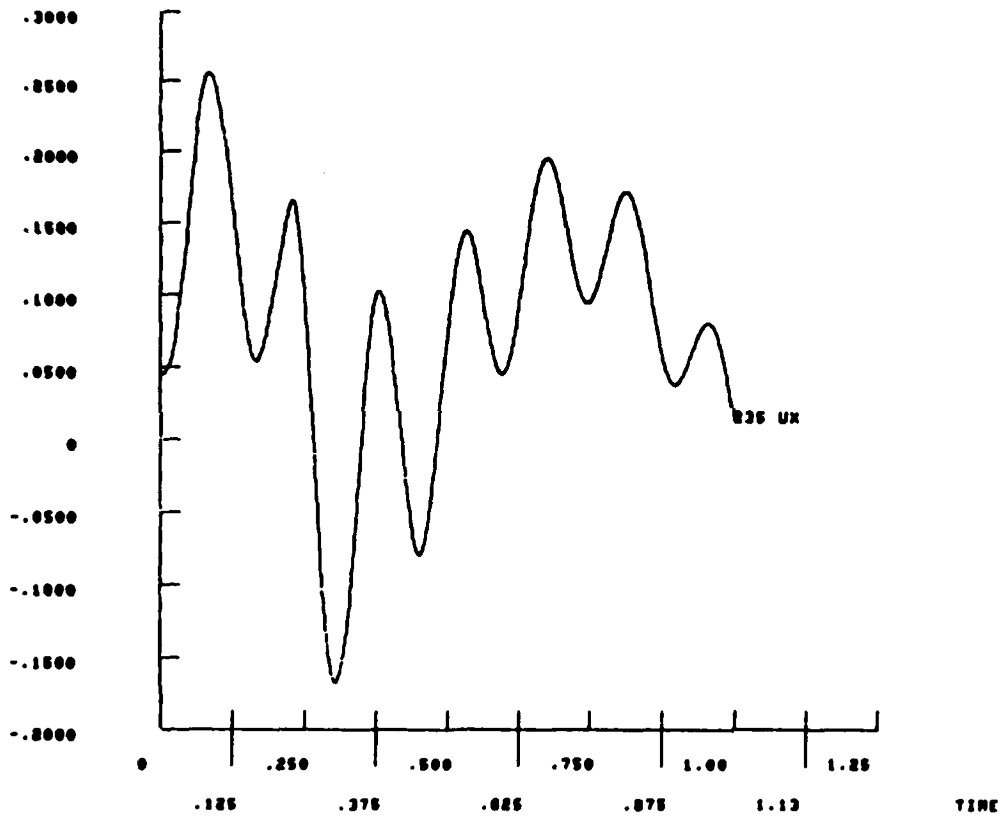

LTHD-22.5.72 CASE,PROOF LOADS

508

(18)

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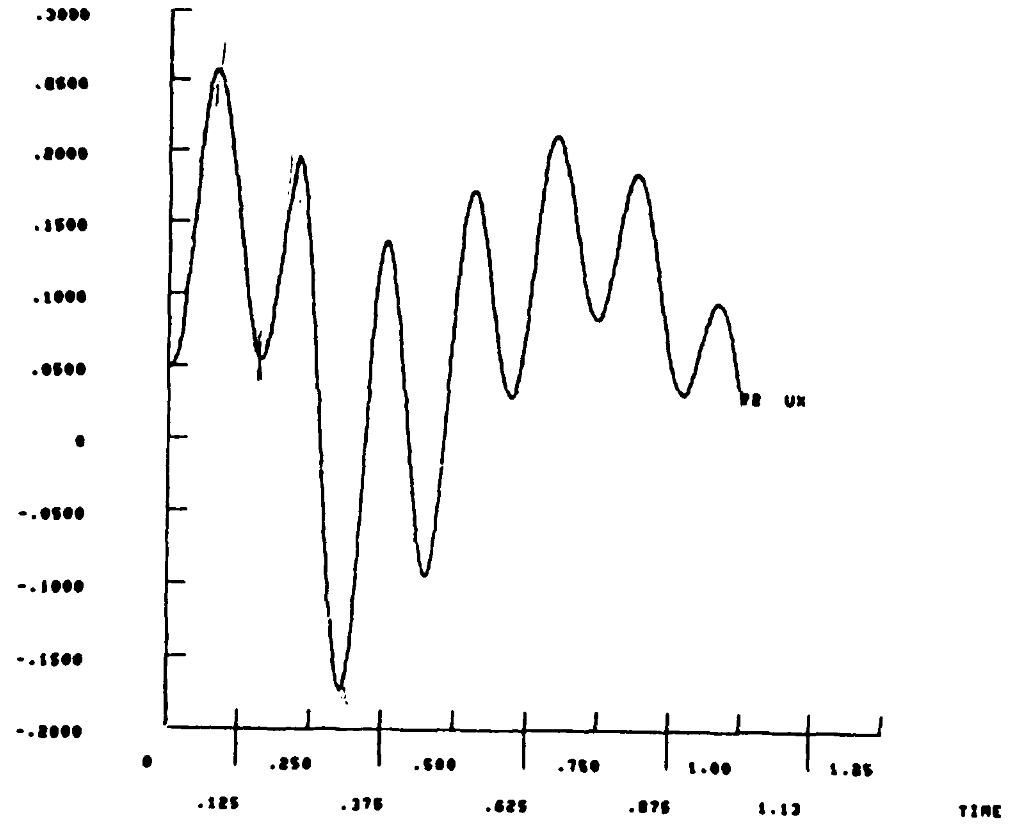

LTMD-22.5.72 CASE,PROOF LOADS

509

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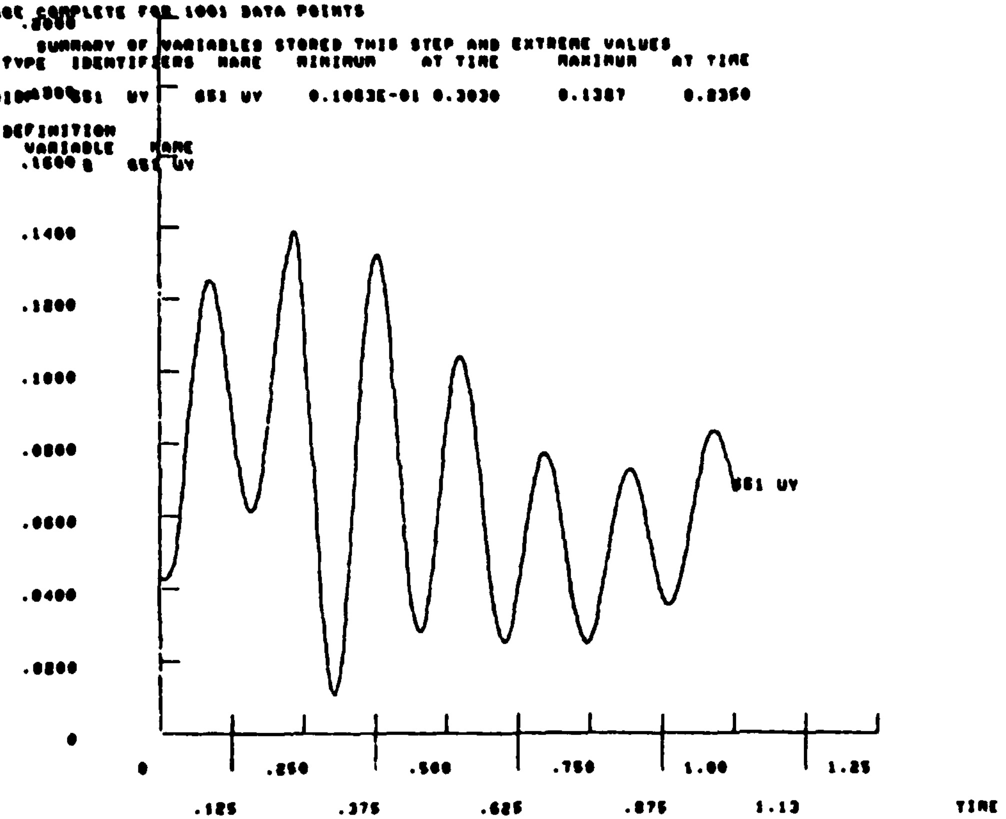

LTHD-88.5,78 CASE,PROOF LOADS

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510

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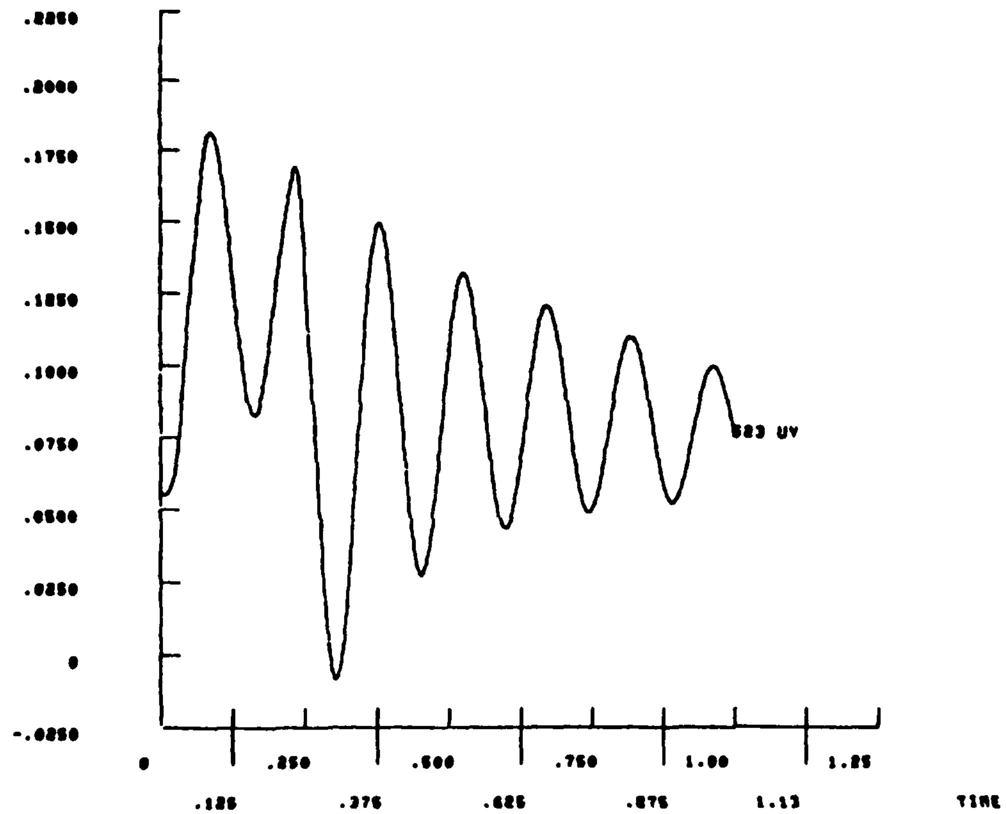
  1       8      523 UV
```



LTHS-22.5,72 CASE,PROOF LOADS

511

(21)

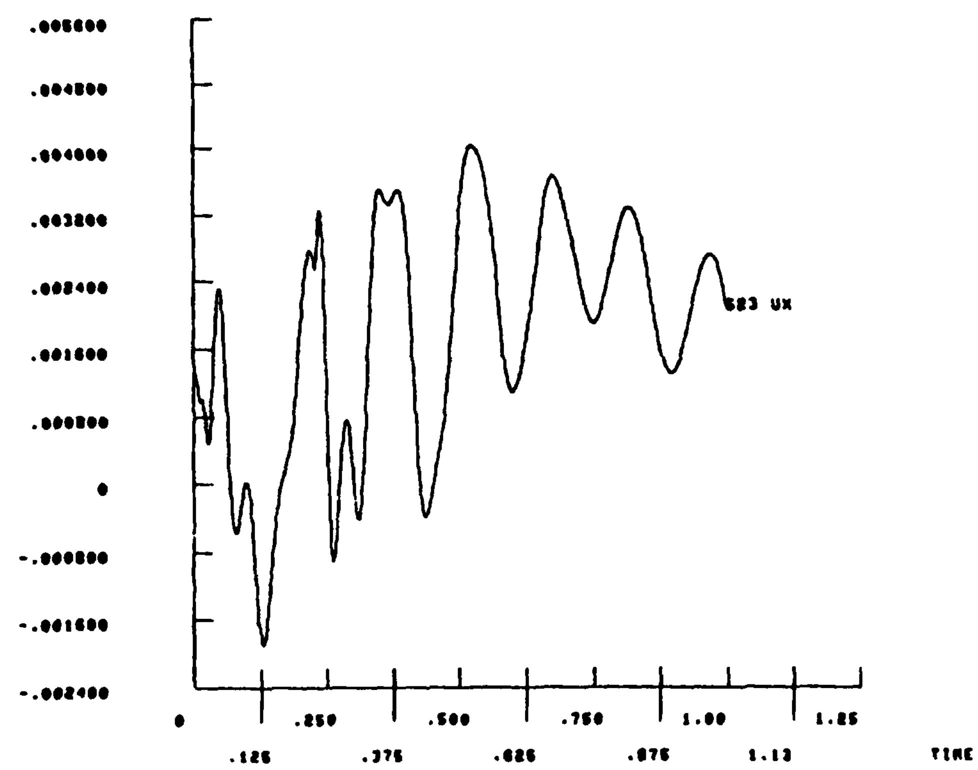
DOUBGGSIBOMPLETE FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES

VARI	TYPE	IDENTIFIERS	NAME	MINIMUM	AT TIME	MAXIMUM	AT TIME
8	DISP	583 UX	583 UX	-0.1893E-02	0.1290	0.4035E-02	0.5210

PLOT DEFINITION VALU

CURVE	VARIABLE	NAME
1	8	583 UX



LTMD-22.5,72 CASE,PROOF LOADS

512

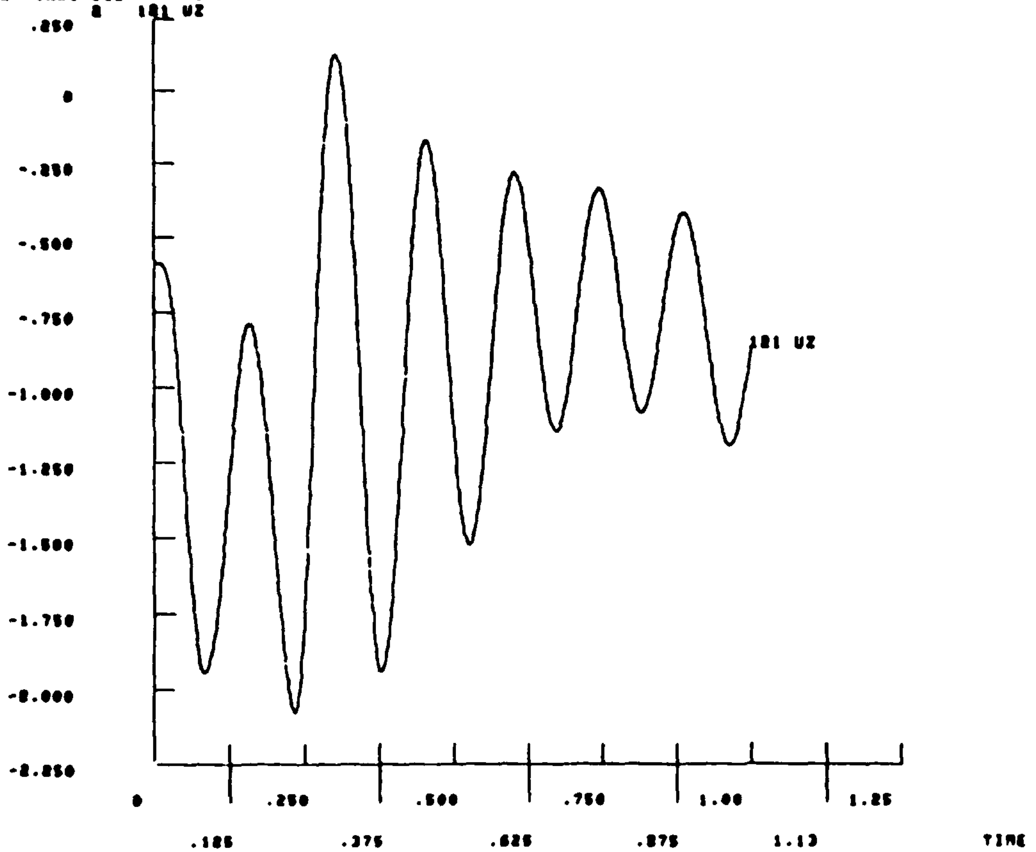
0000000INCOMPLETE FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES

VARI	TYPE	IDENTIFIERS		NAME	MINIMUM	AT TIME	MAXIMUM	AT TIME
2	DISP	VELV 181	UZ	181 UZ	-2.075	0.2350	0.1224	0.3030

PLOT DEFINITION

CURVE	VARIABLE	NAME
1	2	181 UZ



LTND-22.5.72 CASE,PROOF LOADS

513

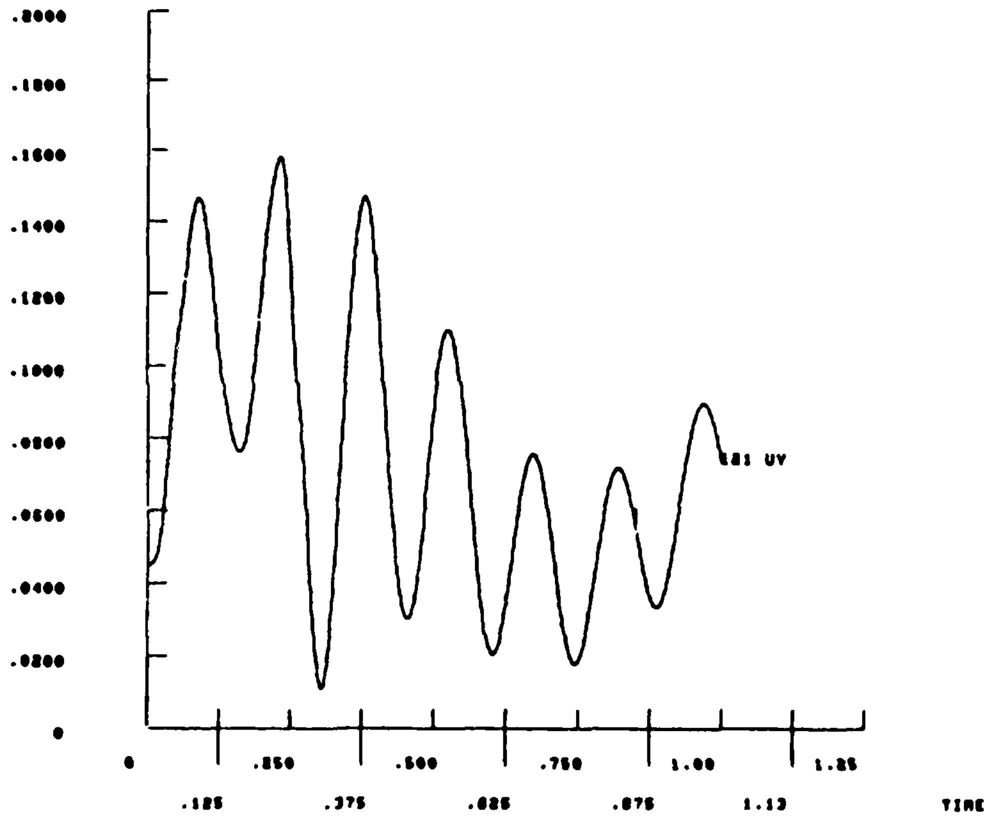
COMPLETE FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES

```
VARI TYPE  IDENTIFIERS  NAME    MINIMUM     AT TIME     MAXIMUM    AT TIME

  2 DISP   181  UV      181 UV  0.1120E-01  0.3040      0.1580     0.2310
           VALU

PLOT DEFINITION
CURVE  VARIABLE   NAME
  1        2     181 UV
```



LTHD-22.5,72 CASE,PROOF LOADS

1

514

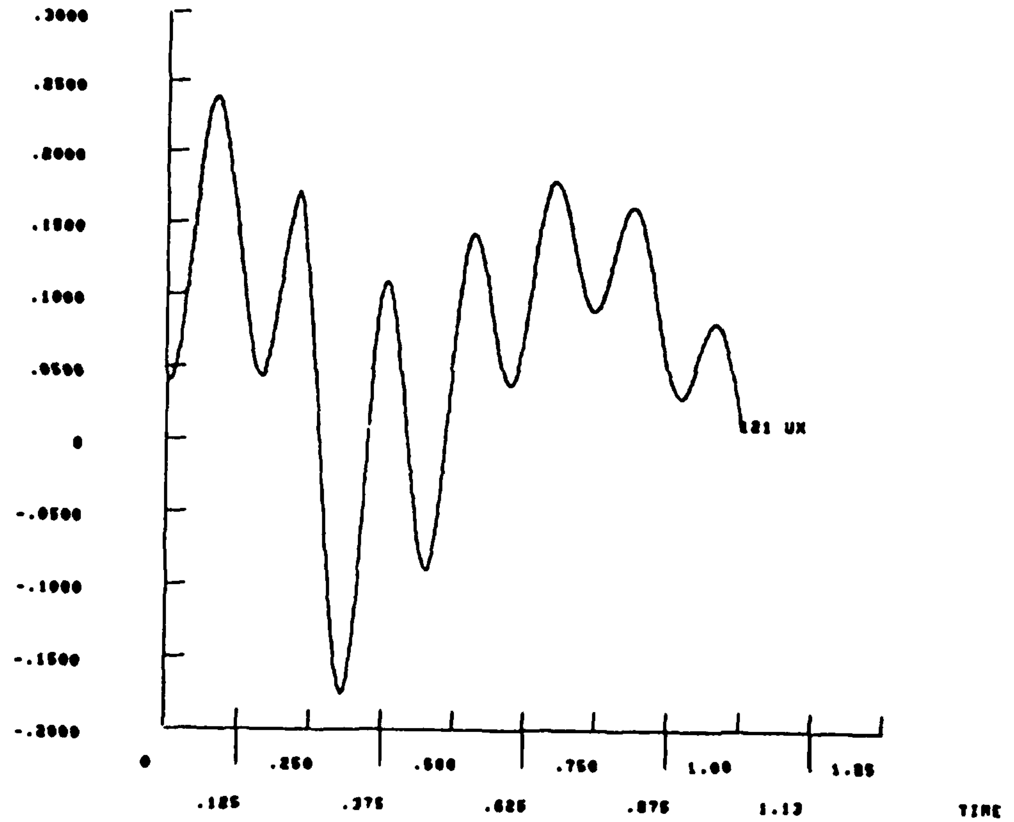
DDDDDDDINCOMPLETE FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES

VARI	TYPE	IDENTIFIERS	NAME	MINIMUM	AT TIME	MAXIMUM	AT TIME
2	DISP	121 UX VALU	121 UX	-0.1751	0.3040	0.2385	0.8400E-01

PLOT DEFINITION

CURVE	VARIABLE	NAME
1	2	121 UX



LTHD-22.5,72 CASE,PROOF LOADS

POSTEG

2V-1

515

25

***WARNING- NODE 3016 DIR= UY IS NOT A MASTER D.O.F.
DISP,2,3010,UX
***WARNING ***   CP= 307.0000   TIME= 13.57858
NO DATA POINTS SAVED THIS STORAGE STEP

VARIABLE 2 IS 3009 UX   PHASE KEY= 0
POSTRS-INP= VALU
PLVA,2

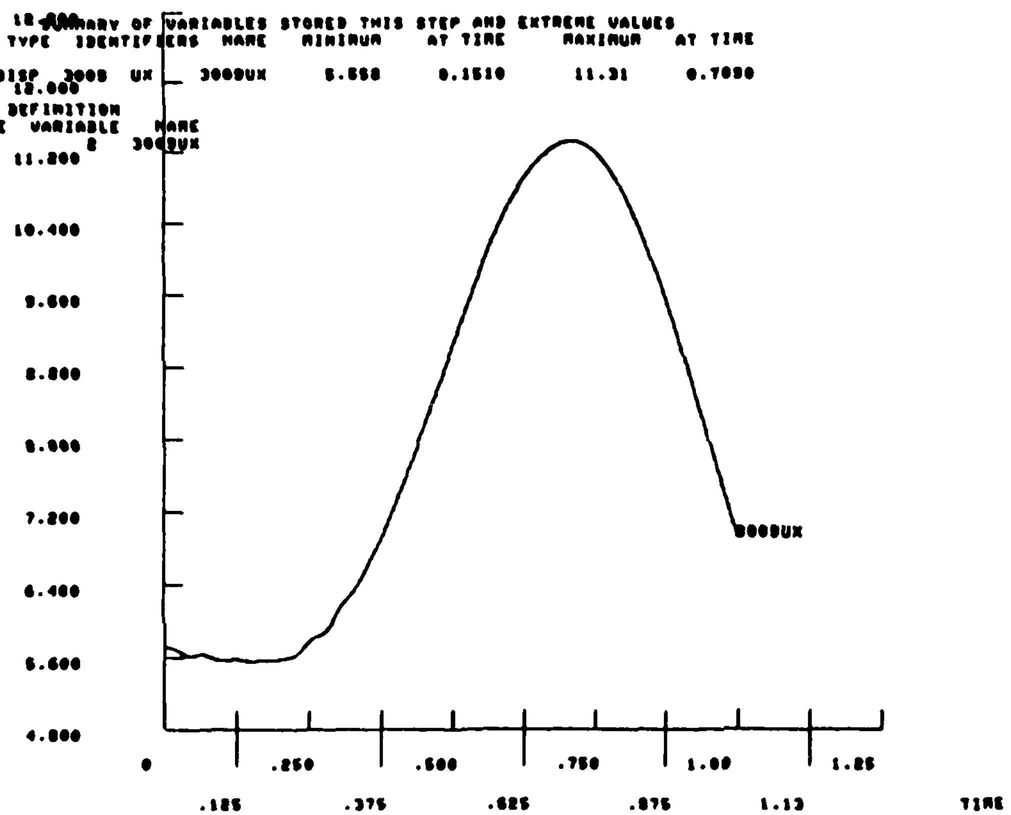
STORAGE COMPLETE FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES

VARI	TYPE	IDENTIFIERS	NAME	MINIMUM	AT TIME	MAXIMUM	AT TIME
2	DISP	3008 UX	3008UX	5.558	0.1510	11.31	0.7030

PLOT DEFINITION

CURVE	VARIABLE	NAME
1	2	3008UX



LTND-22.5,72 CASE,PROOF LOADS

CRADLE FORWARD
END MDOF NODE
(SIDE-TO-SIDE MOTION)

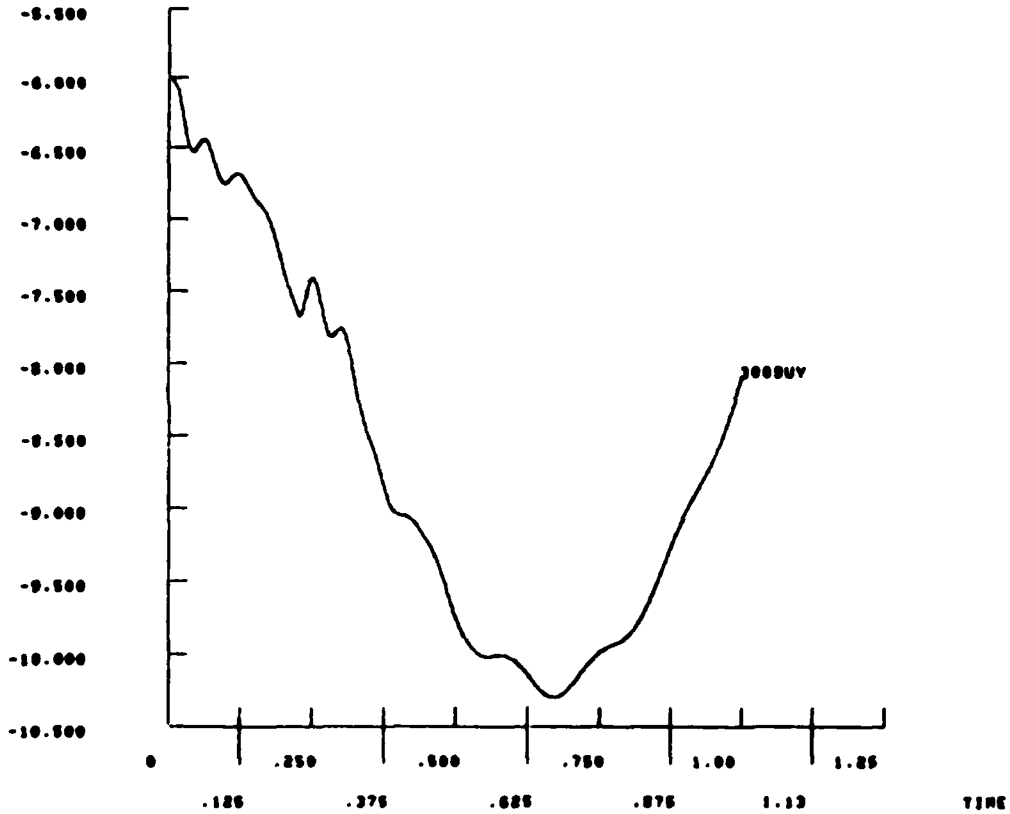
0000000ICOMPLETE FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES

VARI	TYPE	IDENTIFIERS	NAME	MINIMUM	AT TIME	MAXIMUM	AT TIME
2	DISP	3000 UV	3000UV	-10.30	0.6700	-5.985	0.0000E+00

PLOT DEFINITION

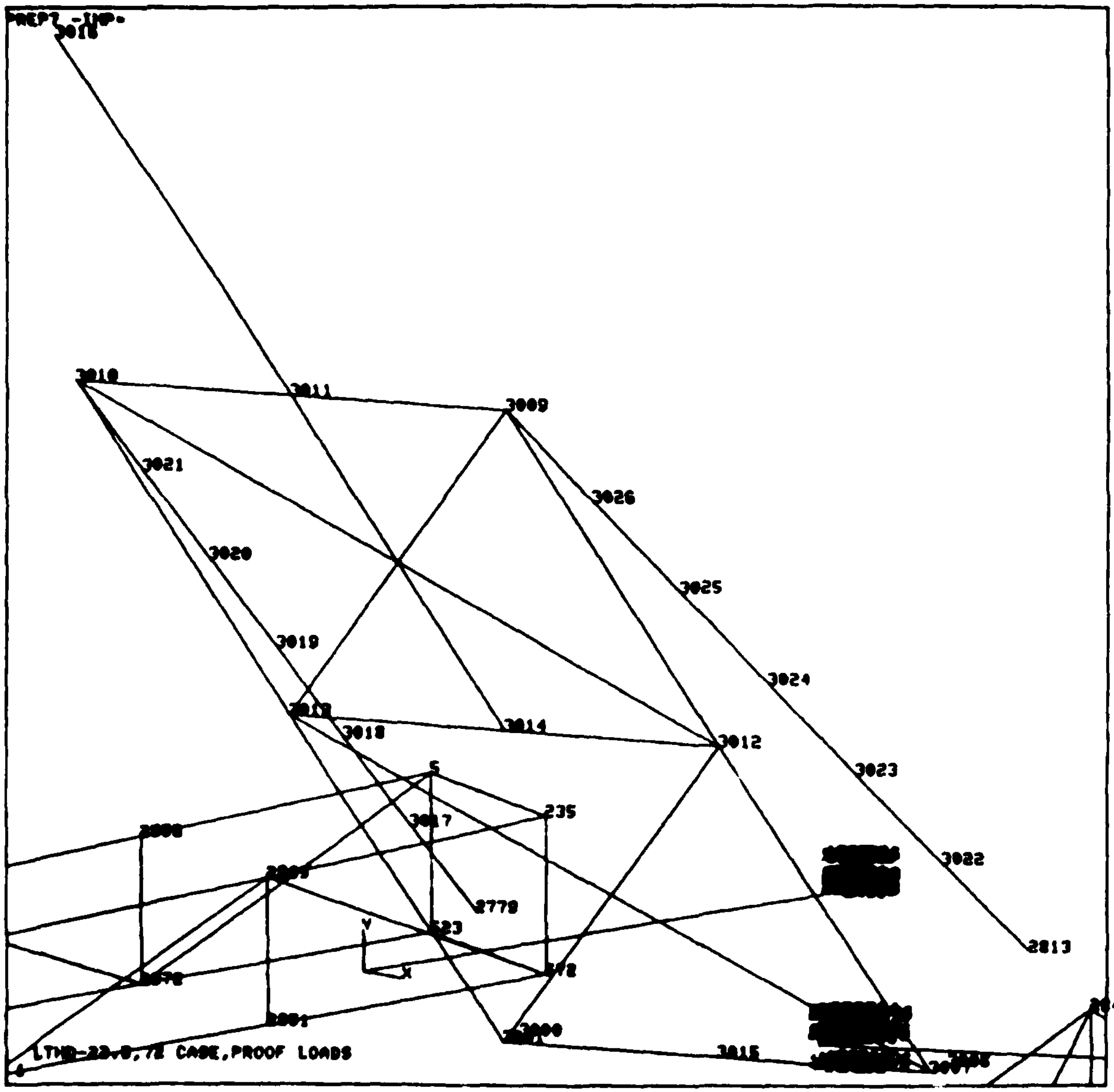
CURVE	VARIABLE	NAME
1	2	3000UV



LTHD-88.5.72 CASE,PROOF LOADS

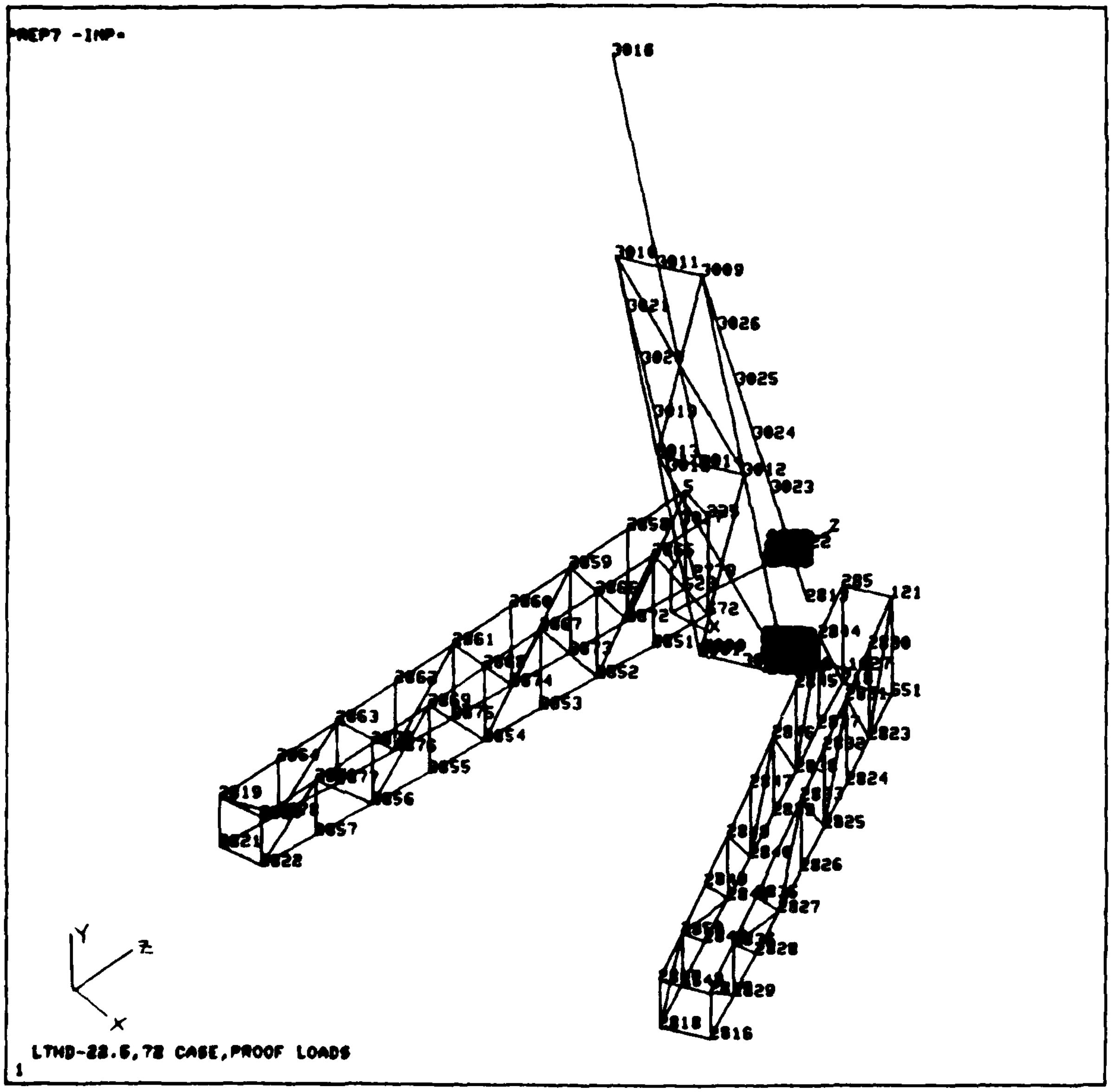
CRADLE FORWARD
END MDOF NODE

517



ANSYS 4.2B
JAN 19 1987
13:30:22
PREP7 ELEMENTS
NNUM=1

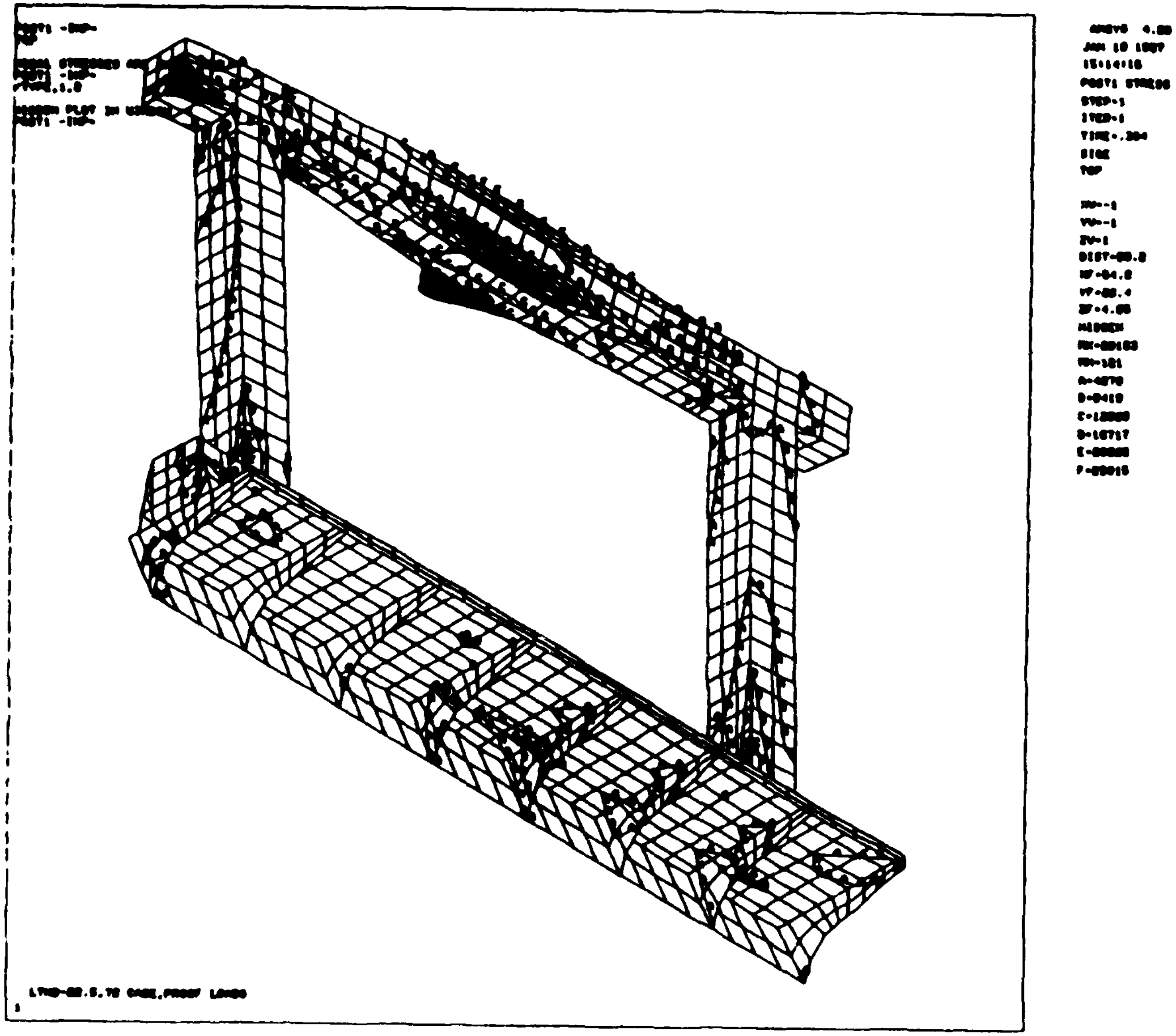
ZOOM
XV=-1
YV=-1
ZV=1
* DIST=482
* XF=77.8
* YF=195
* ZF=-57.8
XRTO=12
YRTO=3.64



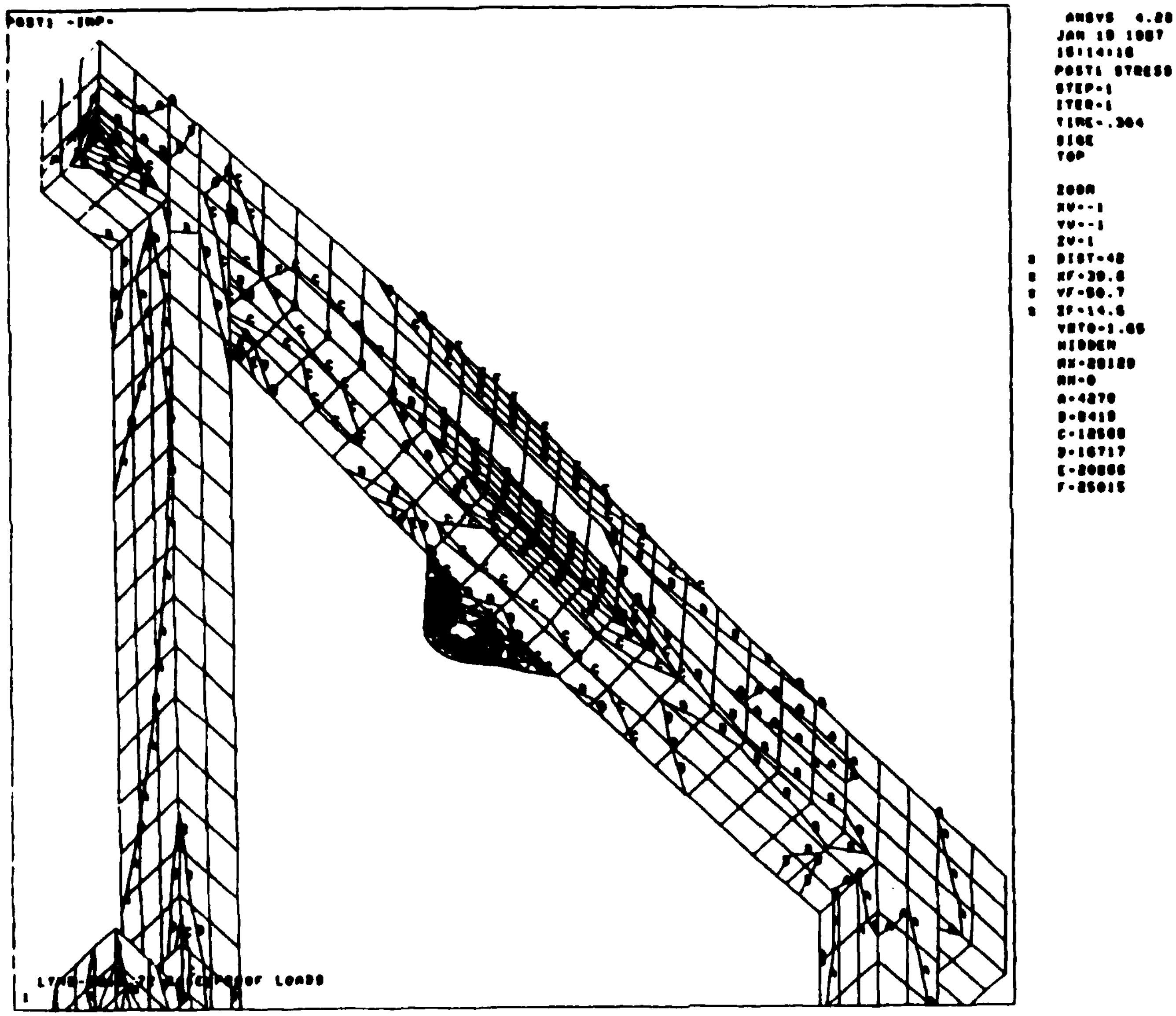
ANSYS 4.2B
JAN 19 1987
13:30:22
PREP7 ELEMENTS
NNUM=1

XV=-1
YV=-1
ZV=1
DIST=811
XF=69.4
YF=132
ZF=-129
XRTO=4.06
YRTO=3.64

520

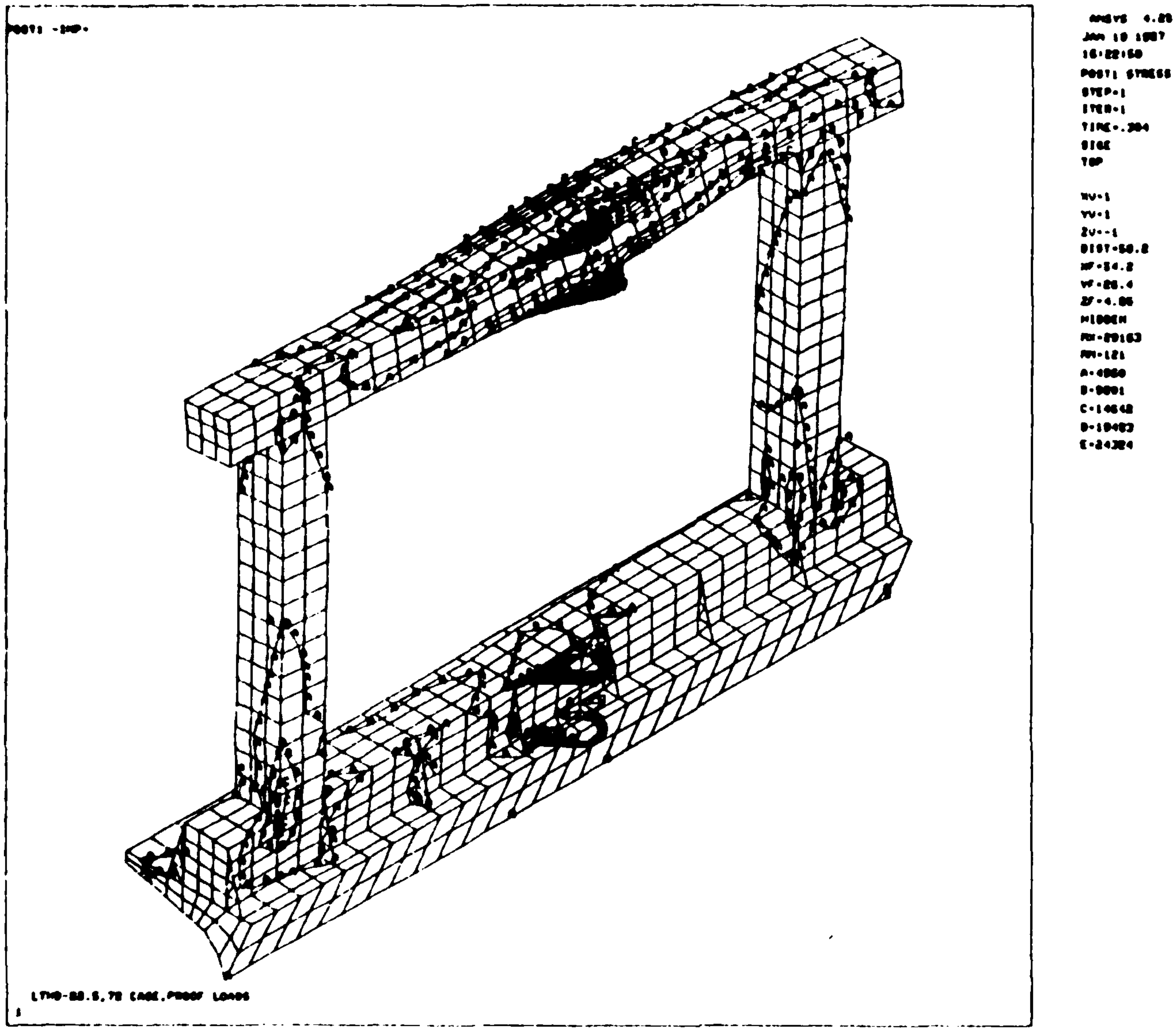


521



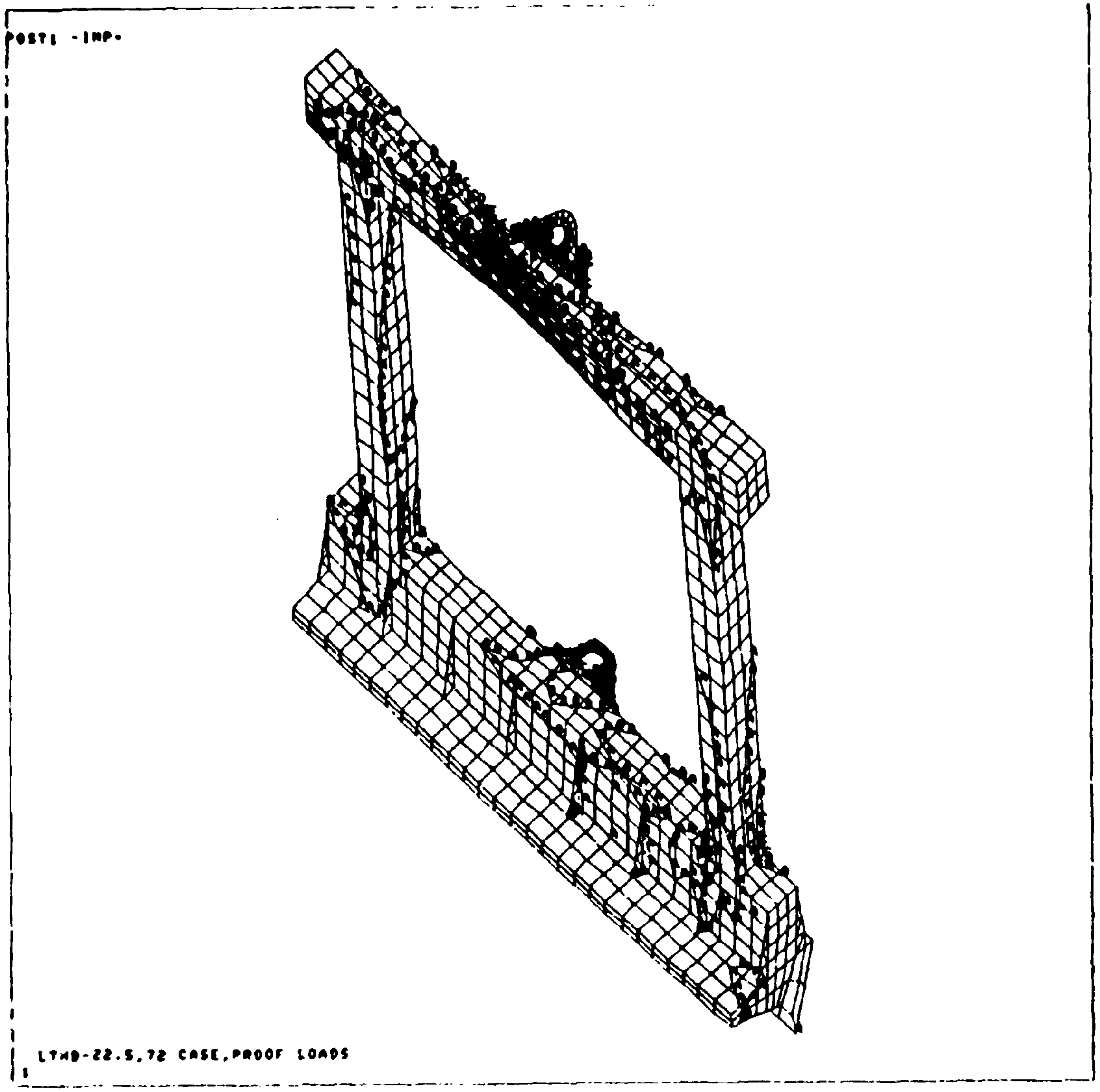
POST1 -INP-
ANSYS
JAN 19 1987
POST1 STRESS
STEP=1
ITER=1
ZOOM
XV=-1
YV=-1
ZV=1
DIST=48
HIDDEN
MN=0
A=4270
D=16717
F=25015
LOADS

522



PLATFORM

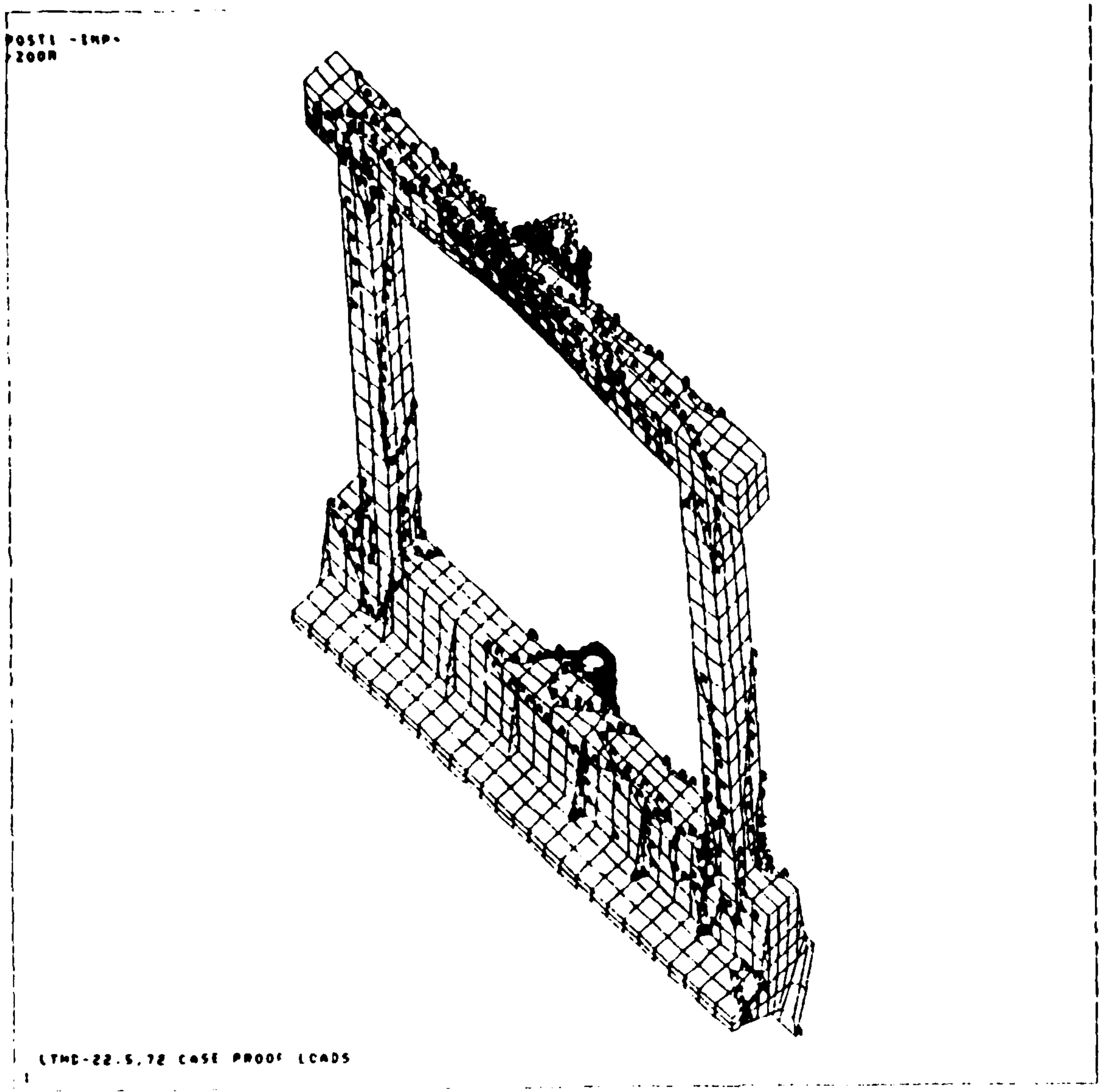
523



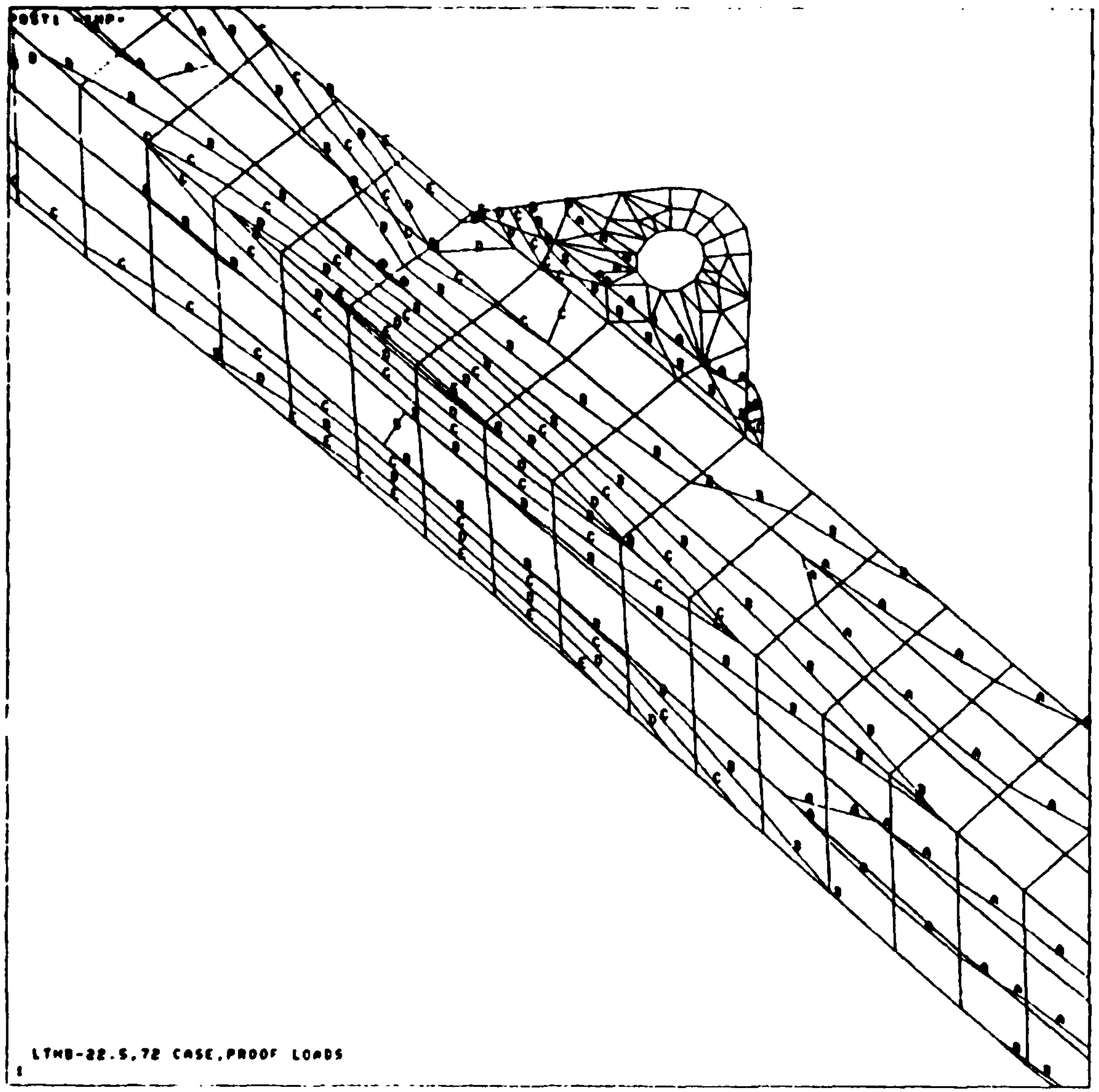
ANSYS 4.2B
JAN 19 1987
15:28:46
POST1 STRESS
STEP=1
ITER=1
TIME=.304
SIGE
TOP

ZOOM
XV=1
YV=1
ZV=1
DIST=93.3
XF=51.2
YF=27.7
ZF=4.17
VRTO=1.85
HIDDEN
MX=29163
MN=121
A=4960
B=9801
C=14642
D=19483
E=24324

524

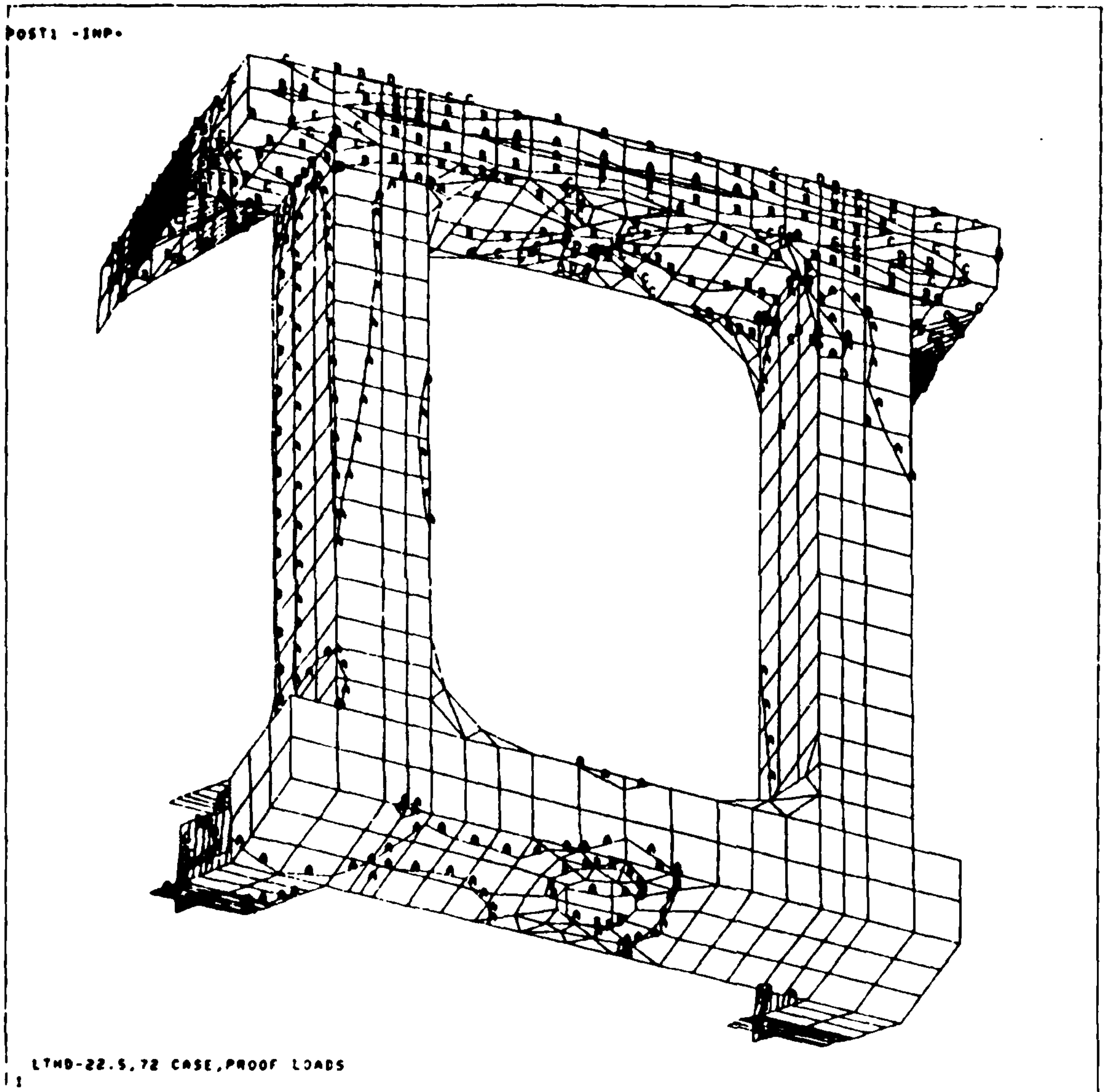

POST1 -INP-
ZOOM
ANSYS 4.28
JAN 19 1987
15:28:46
POST1 STRESS
STEP=1
ITER=1
TIME=.304
SIGE
TOP
ZOOM
XV=1
YV=1
ZV=1
DIST=93.3
XF=51.2
YF=27.7
ZF=4.17
VRTO=1.65
HIDDEN
MX=29163
MN=121
A=4960
B=9801
C=14642
D=19483
E=24324
LTHD-22.5,72 CASE PROOF LOADS

525

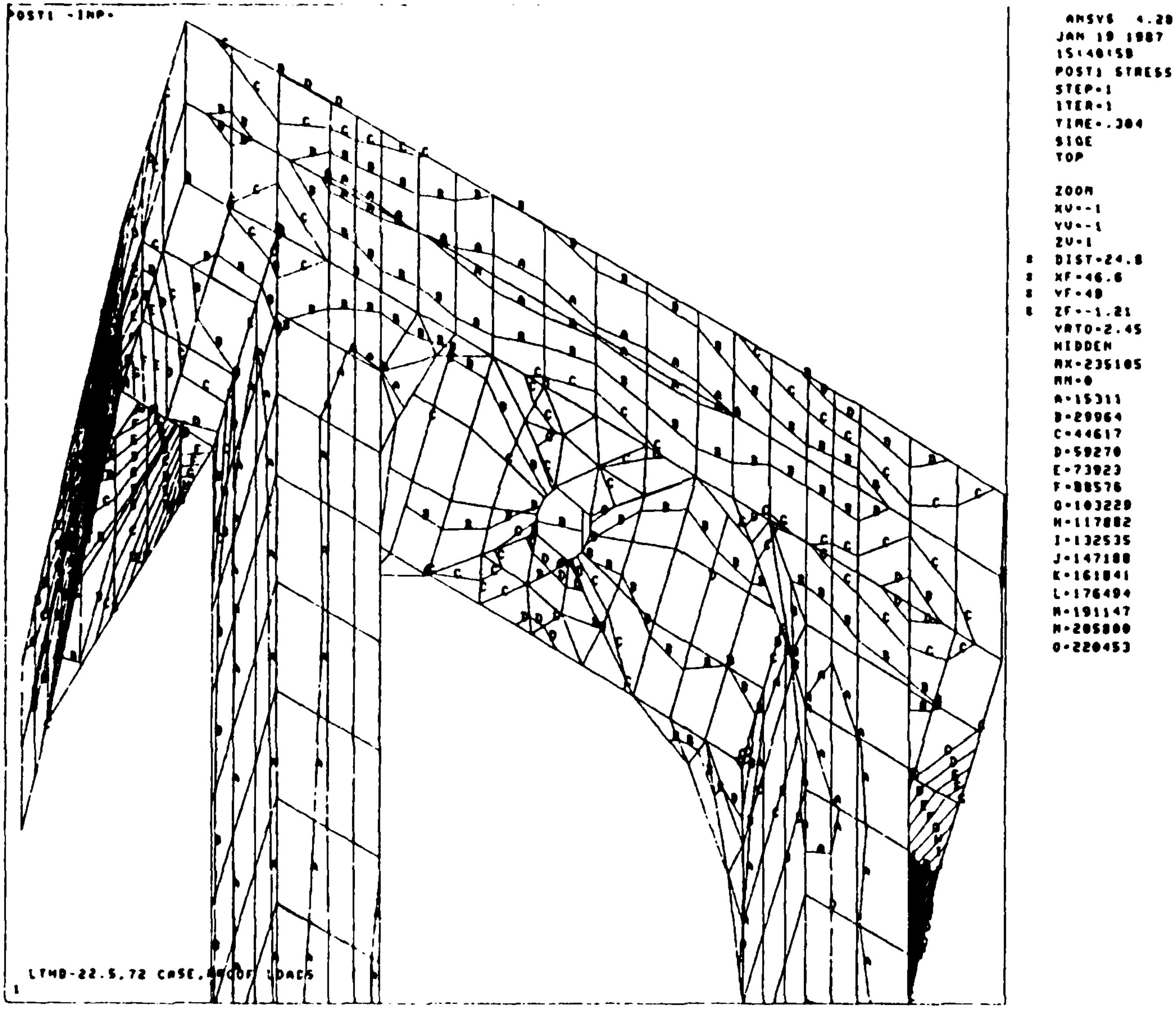


PLATFORM
UPPER BOX
BEAM

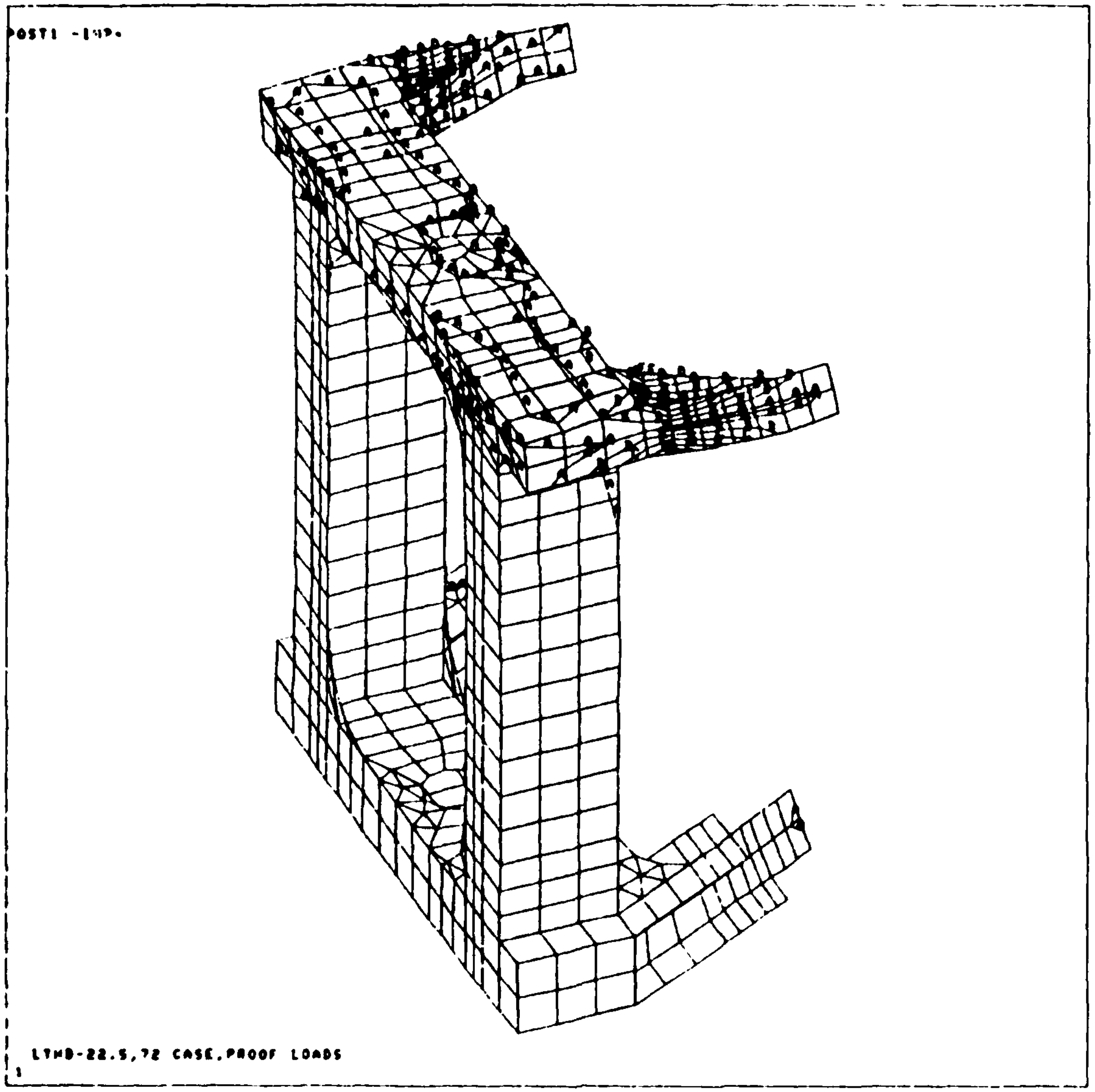
526 (14/14)


POST1 -INP-
LTHD-22.5,72 CASE,PROOF LOADS
1
ANSYS 4.2B
JAN 19 1987
15:40:59
POST1 STRESS
STEP=1
ITER=1
TIME=.304
SIGE
TOP
XV=-1
YV=-1
ZV=1
DIST=29.7
XF=53.9
YF=35
ZF=-7.93
HIDDEN
MX=235105
MN=666
A=15311
B=29964
C=44617
D=59270
E=73923
F=88576
G=103229
H=117882
I=132535
J=147188
K=161841
L=176494
M=191147
N=205800
O=220453

527 (3)

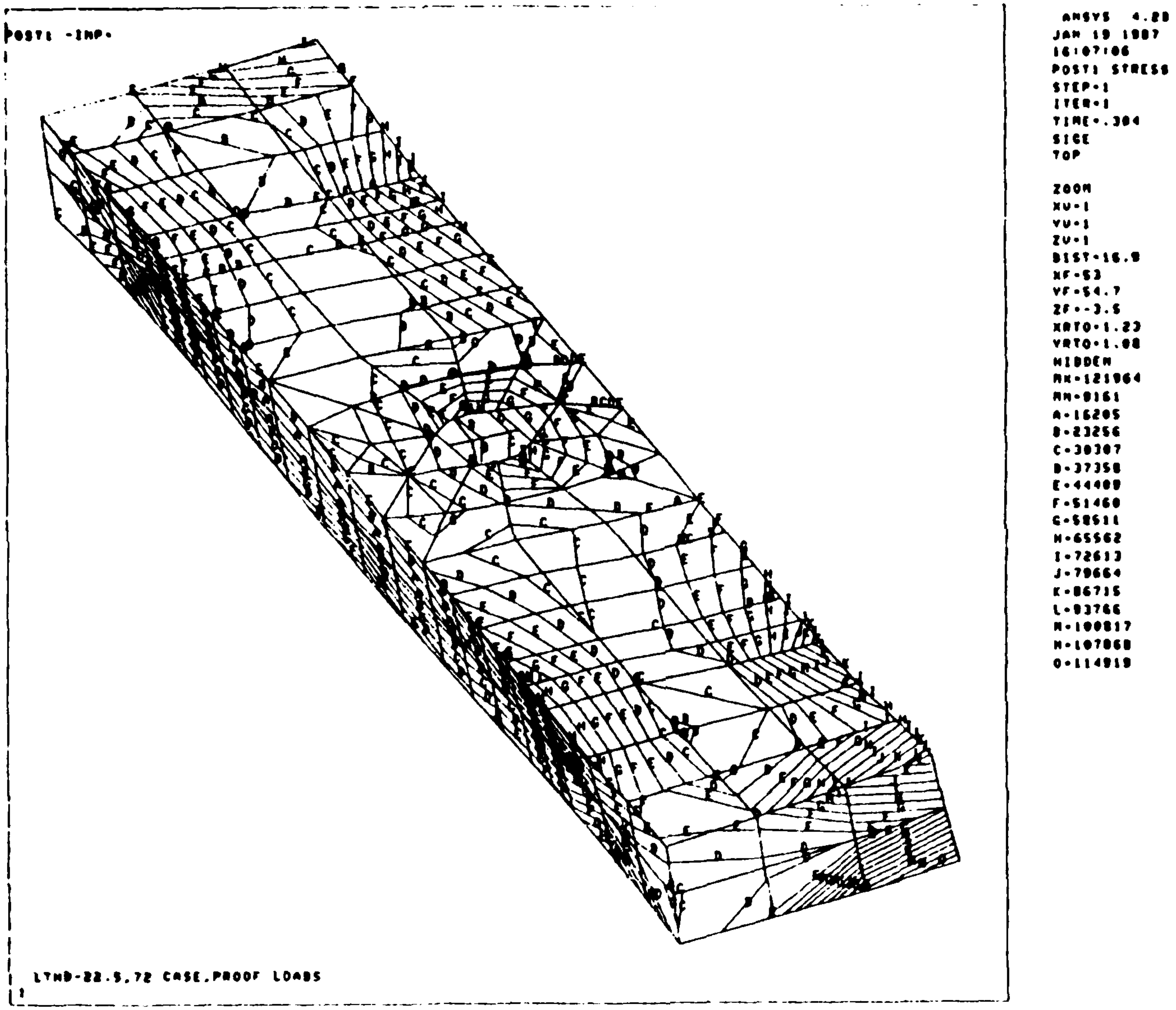

POST1 -INP-
LTMD-22.5.72 CASE, ROOF LOADS
1
ANSYS 4.20
JAN 19 1987
15:40:59
POST1 STRESS
STEP=1
ITER=1
TIME=.304
SIDE
TOP
ZOOM
XV=-1
YV=-1
ZV=1
DIST=24.8
XF=46.6
YF=40
ZF=-1.21
VRTO=2.45
HIDDEN
MX=235105
MN=0
A=15311
B=29964
C=44617
D=59270
E=73923
F=88576
G=103229
H=117882
I=132535
J=147188
K=161841
L=176494
M=191147
N=205800
O=220453

528 (37)



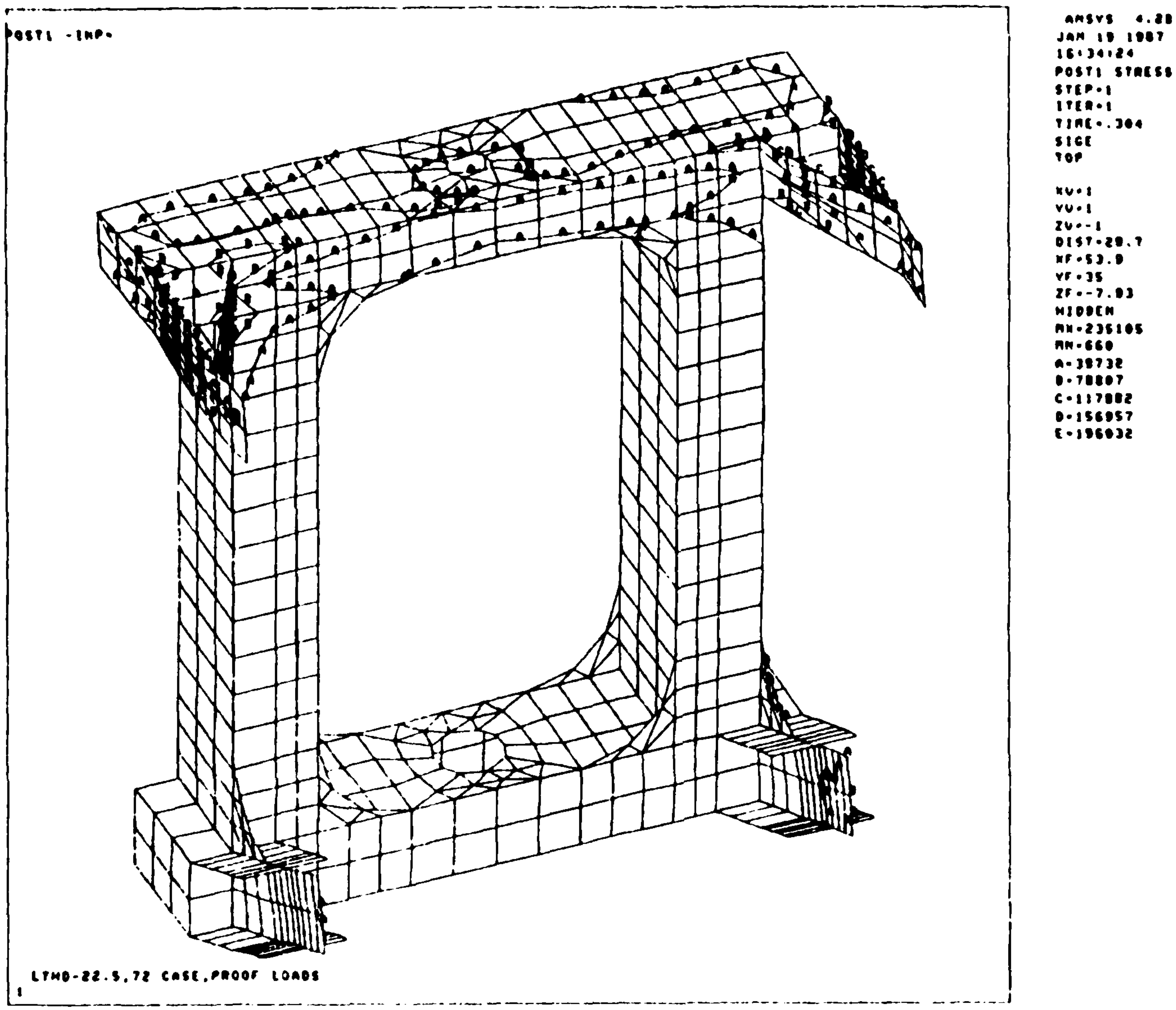
ANSYS 4.2B
JAN 10 1987
15:50:54
POST1 STRESS
STEP=1
ITER=1
TIME=.304
SIGE
TOP

XV=1
YV=1
ZV=1
DIST=34.9
XF=57.3
YF=33.9
ZF=-7.62
HIDDEN
MX=235105
MN=660
A=39732
B=78807
C=117882
D=156957
E=196032



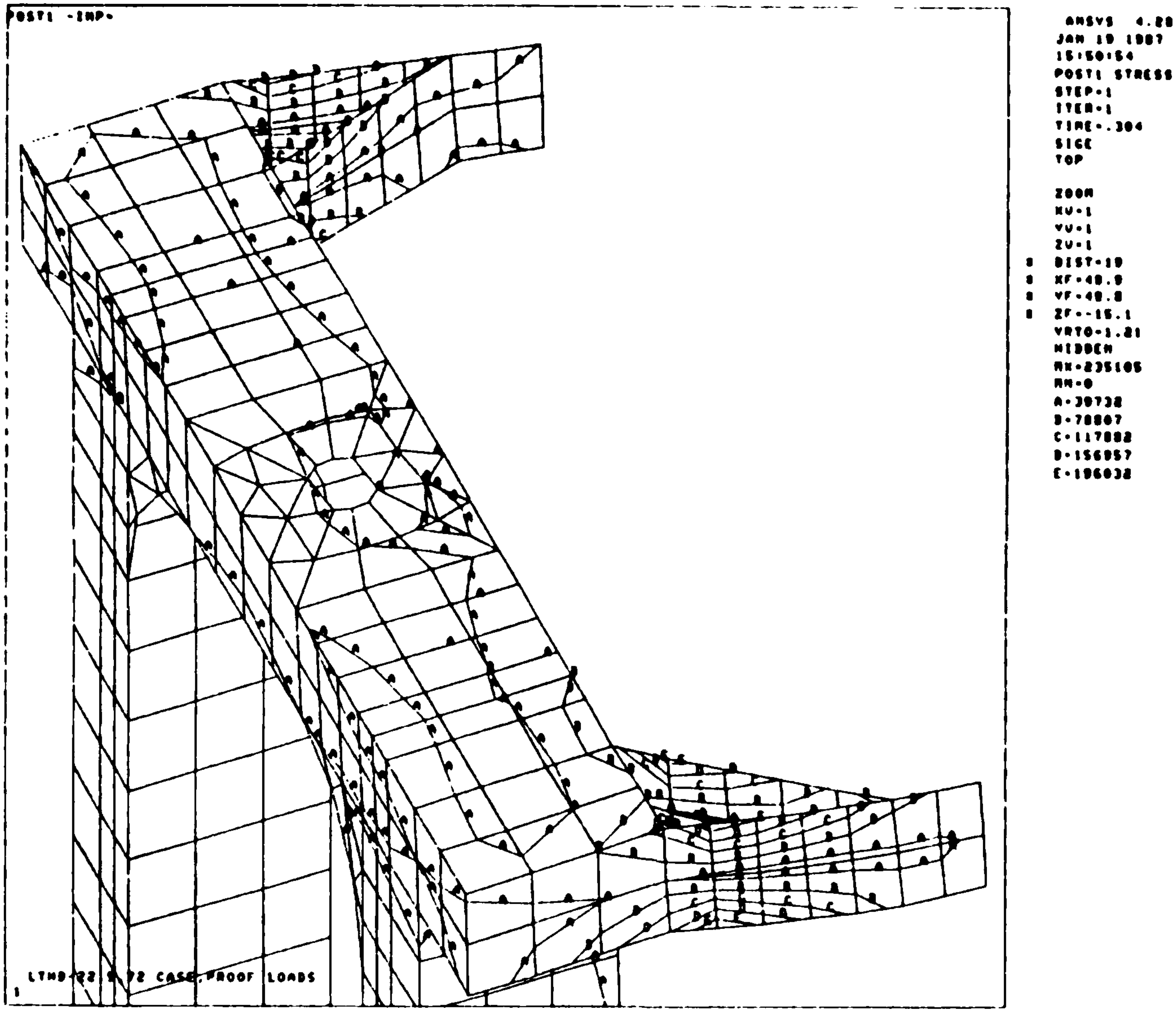
UPPER GIMBAL
BOX BEAM

530

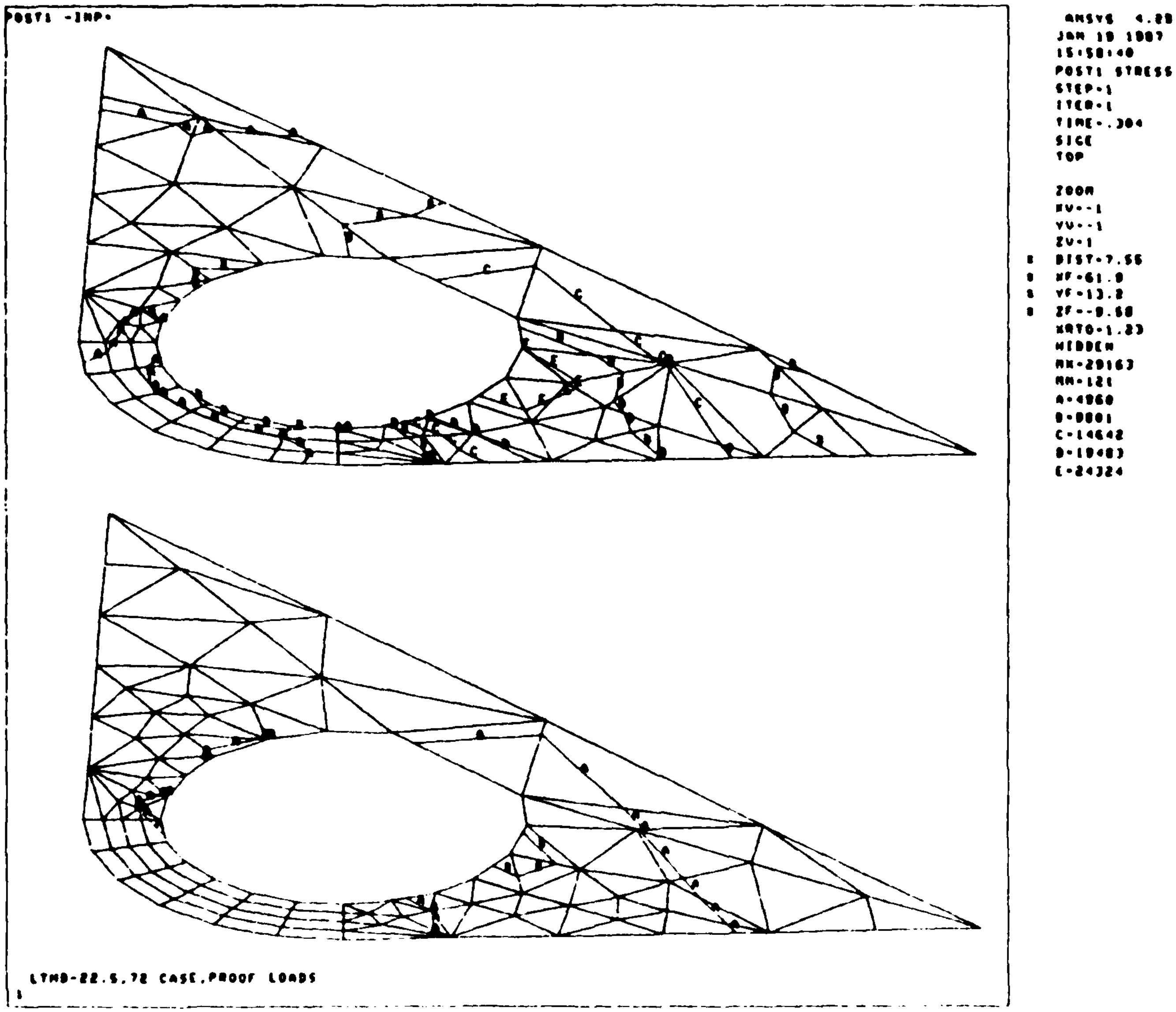

POST1 -INP-
LTMD-22.5,72 CASE,PROOF LOADS
1
ANSYS 4.2B
JAN 19 1987
16:34:24
POST1 STRESS
STEP=1
ITER=1
TIME=.304
SIGE
TOP
XV=1
YV=1
ZV=-1
DIST=28.7
XF=53.9
YF=35
ZF=-7.93
HIDDEN
MX=235105
MN=660
A=39732
B=78807
C=117882
D=156957
E=196032

531

40

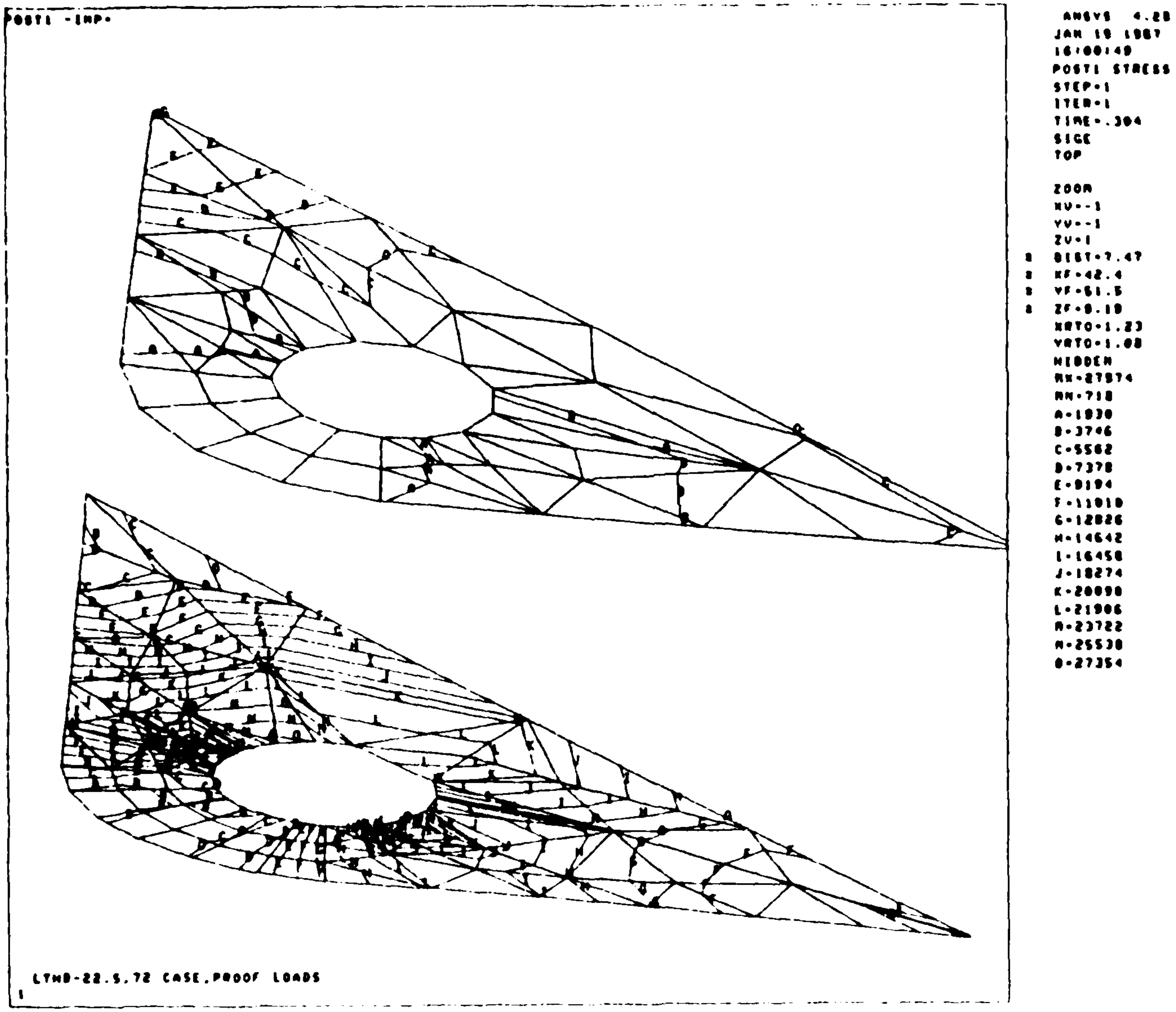

POST1 -INP-
LTHB-22 ... 72 CASE, PROOF LOADS
ANSYS 4.2B
JAN 19 1987
15:50:54
POST1 STRESS
STEP=1
ITER=1
TIME=.304
SIGE
TOP
ZOOM
XV=1
YV=1
ZV=1
DIST=19
XF=40.9
YF=40.8
ZF=-15.1
VRTO=1.21
HIDDEN
MX=235105
MN=0
A=39738
B=78807
C=117882
D=156957
E=196032

532 (41


POST1 -INP-
ANSYS 4.2B
JAN 19 1987
15:58:40
POST1 STRESS
STEP=1
ITER=1
TIME=.304
SIGE
TOP
ZOOM
XV=-1
YV=-1
ZV=1
DIST=7.55
XF=61.0
YF=13.2
ZF=-0.58
XRTO=1.23
HIDDEN
MX=29163
MN=121
A=4960
B=9801
C=14642
D=19483
E=24324
LTMD-22.5.72 CASE,PROOF LOADS

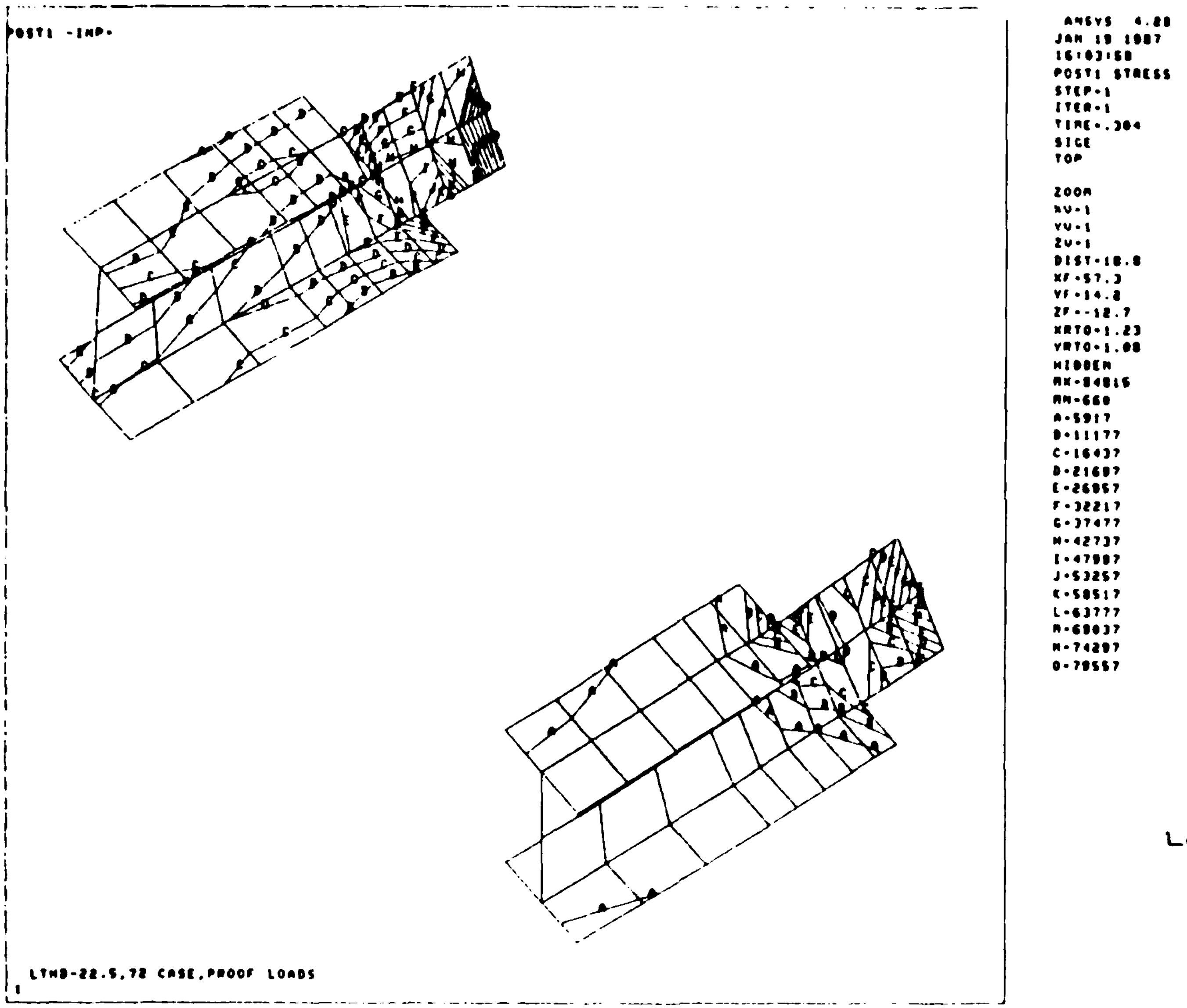
533

BOTTOM



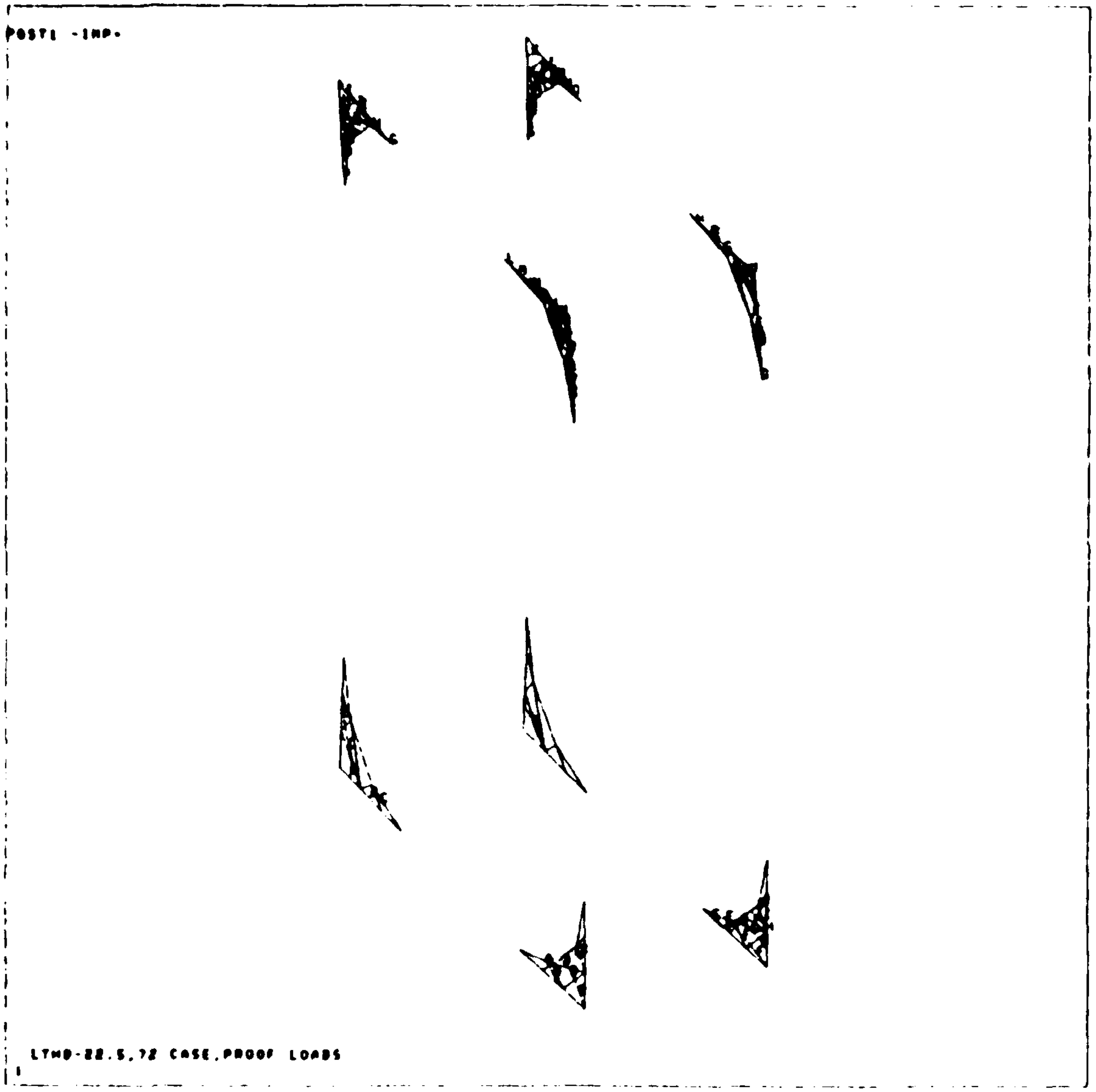
534

UPPER
TABS



LOWER GIMBAL
SUPPORTS

535



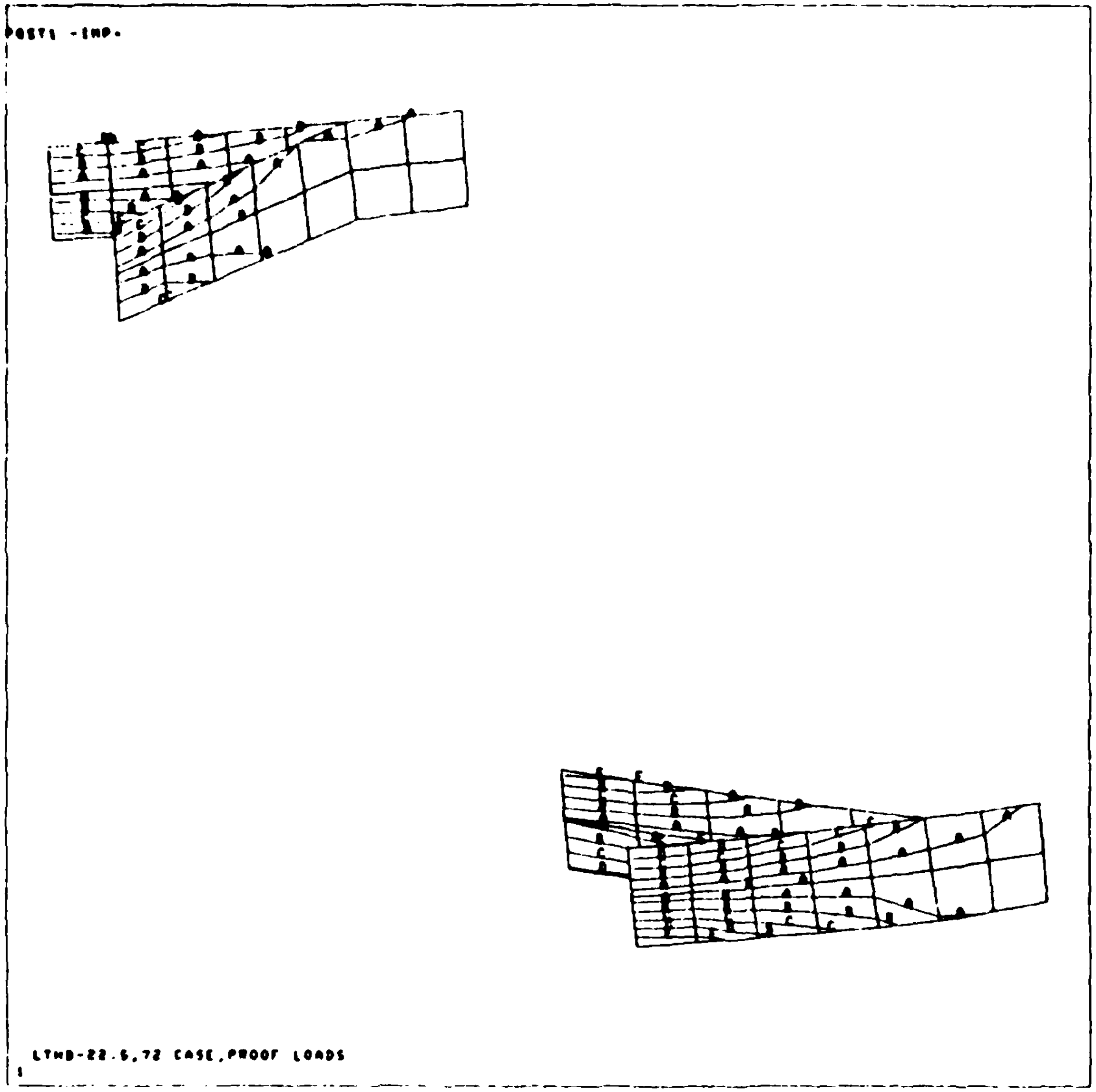
ANSYS 4.2B
JAN 19 1987
16:08:27
POST1 STRESS
STEP=1
ITER=1
TIME=.304
SIGE
TOP

ZOOM
XV=1
YV=1
ZV=1
DIST=26.8
XF=53
YF=33.6
ZF=-3.5
XRTO=1.23
YRTO=1.00
HIDDEN
MX=48794
MN=3461
A=6290
B=9124
C=11958
D=14792
E=17626
F=20460
G=23294
H=26128
I=28962
J=31796
K=34630
L=37464
M=40298
N=43132
O=45966

GIMBAL
REINFORCEMENTS

536

(51)



ANSYS 4.2B
JAN 19 1987
16:18:16
POST1 STRESS
STEP=1
ITER=1
TIME=.304
SIGE
TOP

ZOOM
XV=1
YV=1
ZV=1
DIST=19.4
XF=57.1
YF=53.3
ZF=-13.8
XRTO=1.23
YRTO=1.08
HIDDEN
MX=251091
MN=17468
A=56556
B=95643
C=134730
D=173817
E=212904

UPPER GIMBAL
MOUNTS

537

0.304 sec

```
POSTRES

PRINT ELEMENT STRESS ITEMS PER ELEMENT

       ***** POST1 ELEMENT STRESS LISTING *****

 LOAD STEP     1  ITERATION=     1  SECTION=  1
 TIME=   0.30400          LOAD CASE=  1

 ELEM      SDIR        SDZ        SDY1        SDZ2         SDY2
 3823   -880.37     -102.87     -55.878    -0.34204E-03 -88.706
 3824   -138.57     -30.856     -50.087    -0.43030E-04 -10.407
 3825    306.98     -87.413      4.9778    -0.00767E-05 -8.0888
 3826    100.73     -7.0000      3.5498    -0.13834E-05  0.31601
 3827    19.868     -0.1466     -0.33000   -0.10611E-05  0.44305E-01
 3828    87.670      10.448      0.53685    0.80315E-05  0.88383E-01
 3829   -194.13      31.418     -1.1098     0.30224E-05 -0.38610
 3830   -1347.8      48.330     -4.8613     0.11370E-04 -0.66813
 3831   -991.58      51.877      1.0859     0.44065E-04  0.78336
 3832   -895.88      89.406      84.038     0.12970E-03  9.6455
 3833   -1864.1      4.5378     -85.686     0.13085E-03 -8.0697
 3834   -888.08     -80.411     -44.789     0.98074E-05 -18.918
 3835   -733.45      81.082      14.231     0.15624E-03  5.7771
 3836   -1003.1      21.157      6.0061     0.10845E-03  3.0460
MORE (YES,NO OR CONTINUOUS)=
C

       ***** POST1 ELEMENT STRESS LISTING *****

 LOAD STEP     1  ITERATION=     1  SECTION=  1
 TIME=   0.30400          LOAD CASE=  1

 ELEM      SDIR        SDZ        SDY1        SDZ2         SDY2
 3838   -1687.7      34.089      11.666     0.20687E-03  9.3019
 3839   -1707.0      86.150      38.905     0.19083E-03  11.140
 3840   -107.88      113.73      48.469    -0.10601E-04  14.404
 3841   -747.86      38.057     -6.9443     0.16450E-03 -3.5107
 3842    100.73     -7.0000      3.5498    -0.13834E-05  0.31601
 3843    666.43      44.543     -4.1068     0.18135E-03 -8.0560
 3844    1638.9     -4.8970     -12.884     0.10514E-03 -6.3046
 3845    507.34     -109.44     -86.251    -0.78000E-03 -9.0603
 3846   -159.66     -125.16     -6.1240    -0.86015E-03 -3.0629
 3847   -483.78     -123.45     -8.8334    -0.87579E-03 -1.9043
 3848    380.96      60.771      47.462     0.15865E-03  13.077
 3849    1633.6      50.710      31.018     0.35378E-03  10.408
 3850    1065.1      27.970      7.3092     0.80911E-03  3.5309
 3851    773.10     -108.16     -51.820    -0.53728E-03 -15.806

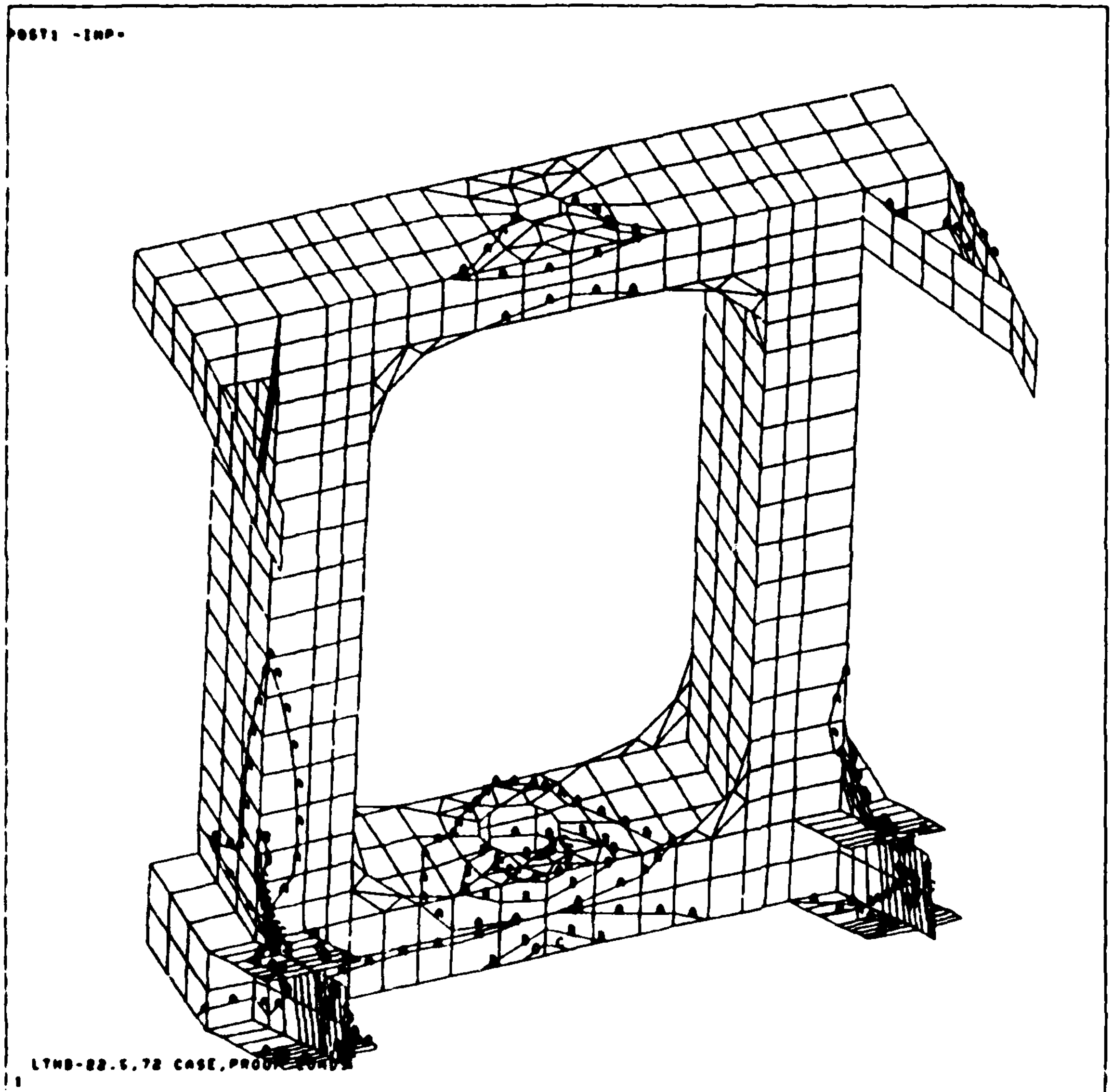
       ***** POST1 ELEMENT STRESS LISTING *****

 LOAD STEP     1  ITERATION=     1  SECTION=  1
 TIME=   0.30400          LOAD CASE=  1

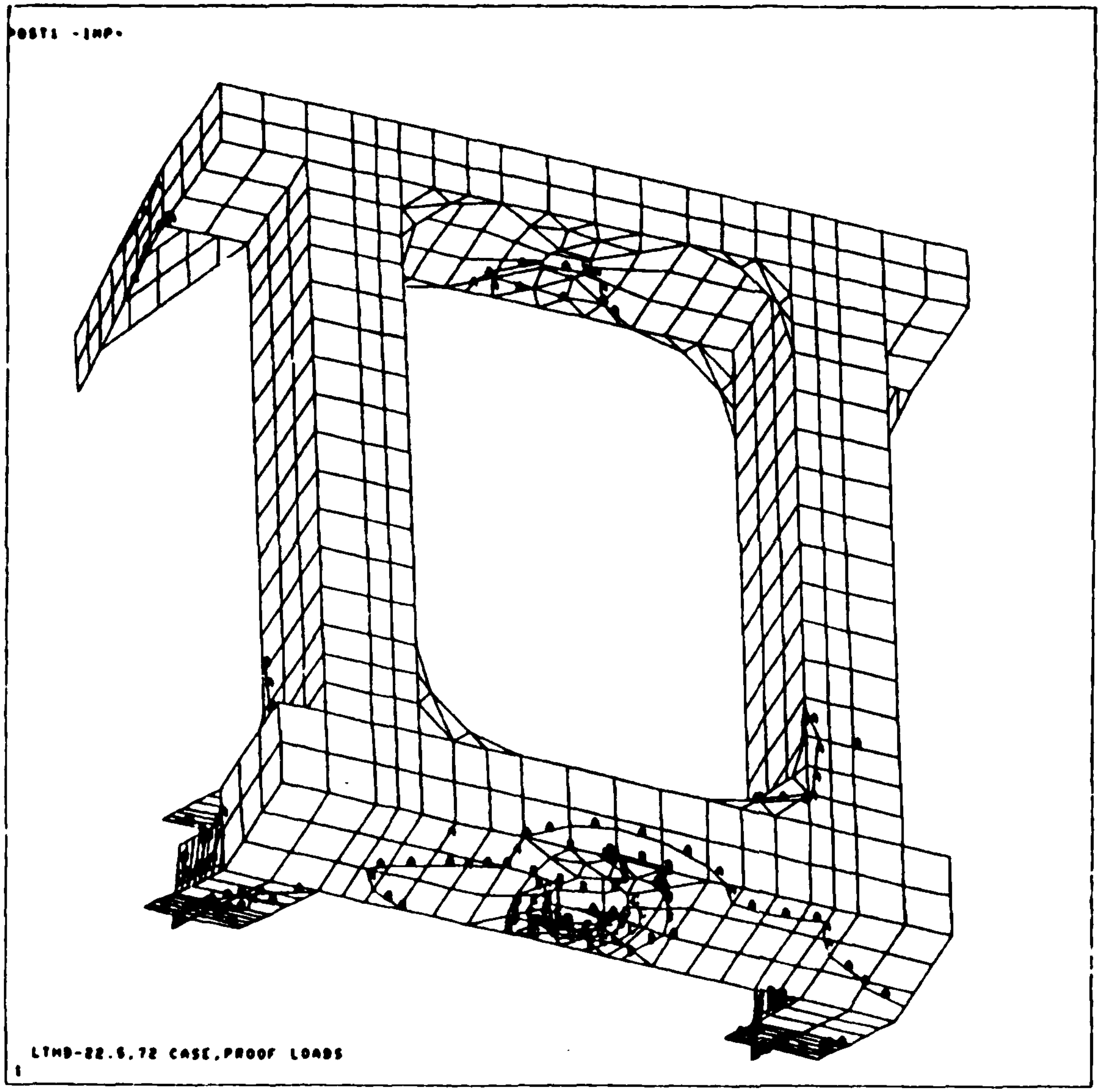
 ELEM      SDIR        SDZ        SDY1        SDZ2         SDY2
 3852    3041.7     -132.98      27.926    -0.54244E-04-0.53784
 3853    815.43     -62.877      3.3594    -0.23097E-04  0.05400
 3854   -3045.8      99.380     -11.409     0.60006E-04 -8.6148
 3855    2906.4     -103.36     -106.98    -0.21818E-03 -33.741
 3856    1670.0     -173.21     -176.21    -0.20300E-02 -66.729
 3857   -103.59      200.63      89.309     0.80340E-03  33.012
 3858   -770.98     -121.76     -8.5533    -0.81304E-03 -3.8751
 3859    1065.1      27.970      7.3092     0.80911E-03  3.5309
 3860    1374.1      161.73      20.103     0.62302E-03  8.8400
 3861   -1434.4      90.103      6.2210     0.19135E-03  1.2526
 3862    1006.9     -4.6383     -5.9018    -0.46291       1.0008
POST1 -INP=
```

538

(47)


POST1 -INP-
LTHB-22.5,72 CASE,PROOF LOADS
1
ANSYS 4.2B
JAN 20 1987
17:09:54
POST1 STRESS
STEP=1
ITER=1
TIME=.084
SIGE
TOP
XV=1
YV=1
ZV=-1
DIST=20.7
XF=53.9
YF=35
ZF=-7.93
HIDDEN
MX=165003
MN=284
A=27735
B=55189
C=82643
D=110097
E=137551

540

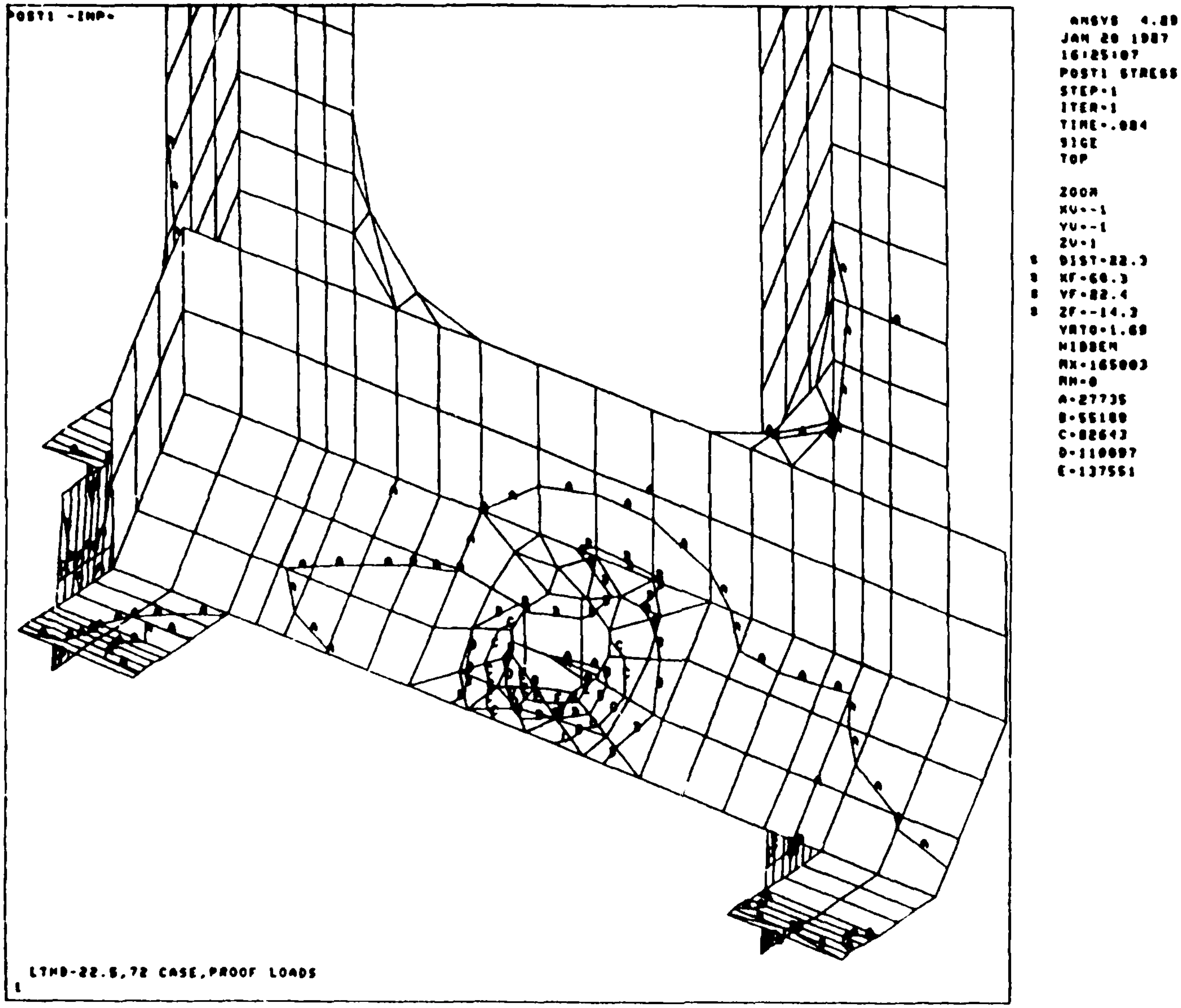


ANSYS 4.2B
JAN 20 1987
16:25:07
POST1 STRESS
STEP=1
ITER=1
TIME=.084
SIGE
TOP

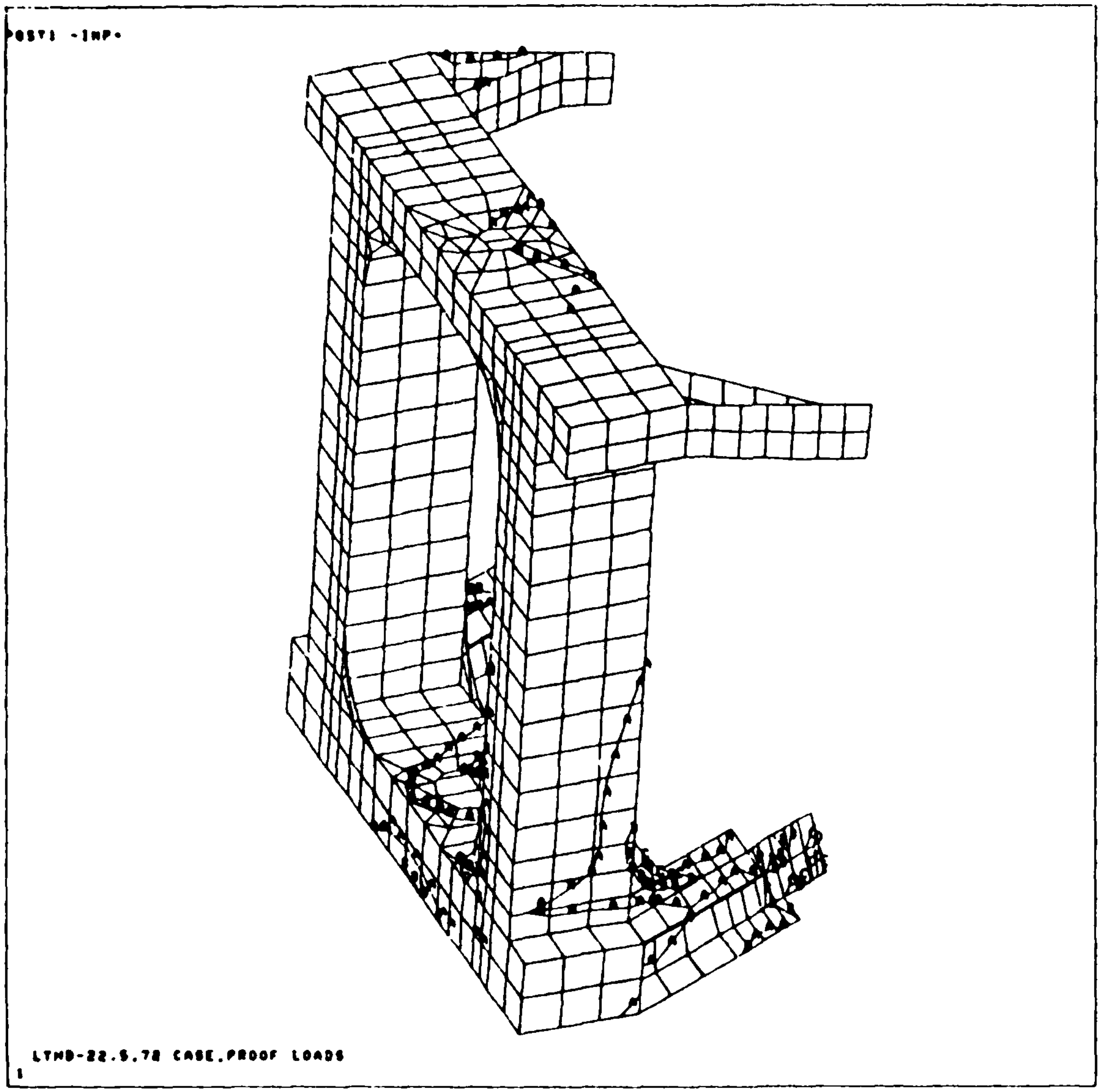
XV=-1
YV=-1
ZV=1
DIST=29.7
XF=53.8
YF=35
ZF=-7.93
HIDDEN
MX=165093
MN=284
A=27726
B=55169
C=82643
D=110097
E=137551

541

(49)


POST1 -INP-
LTHD-22.5,72 CASE,PROOF LOADS
ANSYS 4.2D
JAN 20 1987
16:25:07
POST1 STRESS
STEP=1
ITER=1
TIME=.084
SIGE
TOP
ZOOM
XV=-1
YV=-1
ZV=1
DIST=22.3
XF=60.3
YF=22.4
ZF=-14.3
VRTO=1.69
HIDDEN
MX=165003
MN=0
A=27735
B=55189
C=82643
D=110097
E=137551

542

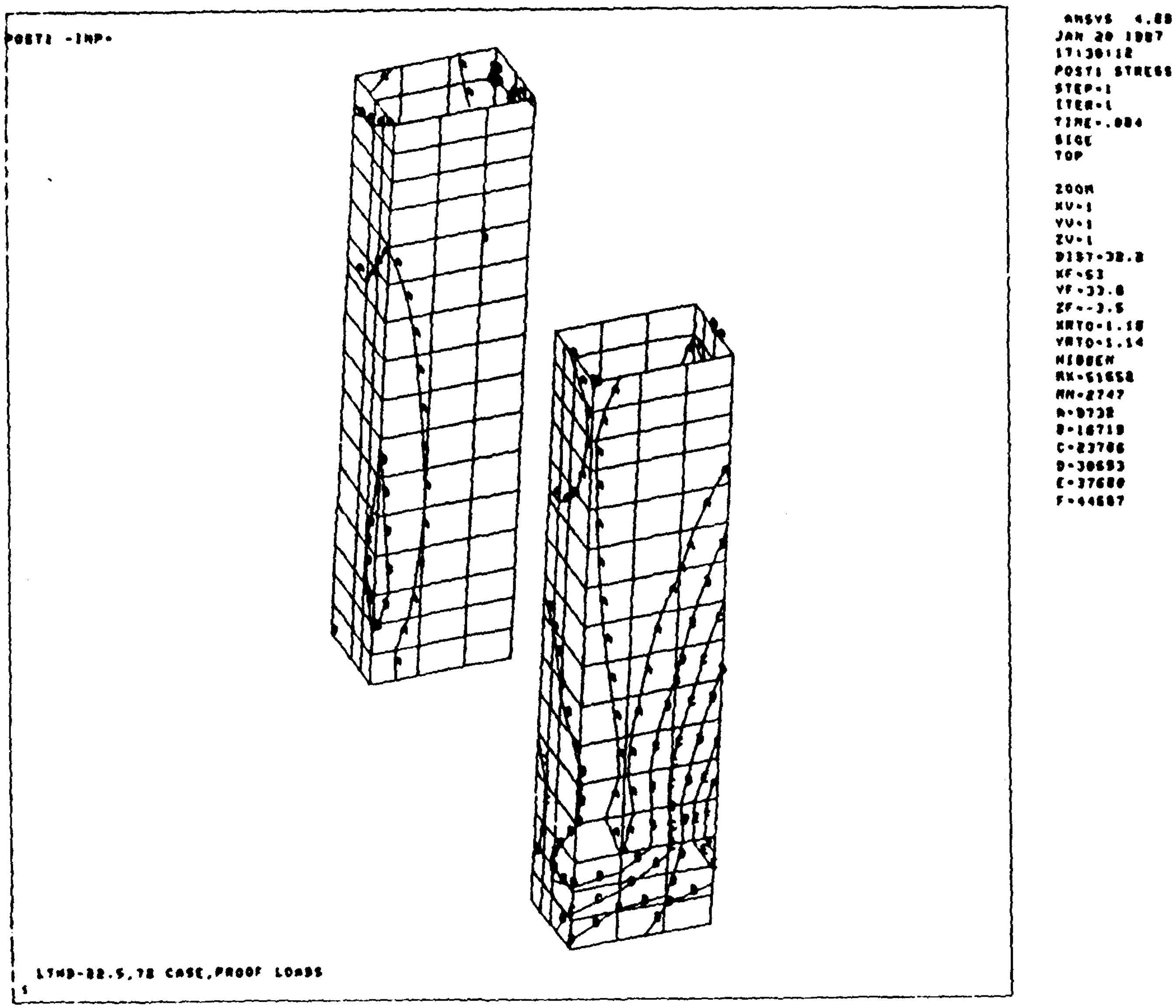


ANSYS 4.2B
JAN 20 1987
17:05:34
POST1 STRESS
STEP=1
ITER=1
TIME=.084
SIGE
TOP

XV=1
YV=1
ZV=1
DIST=34.9
XF=57.3
YF=33.9
ZF=-7.68
HIDDEN
MX=165003
MN=284
A=27735
B=55189
C=82643
D=110097
E=137551

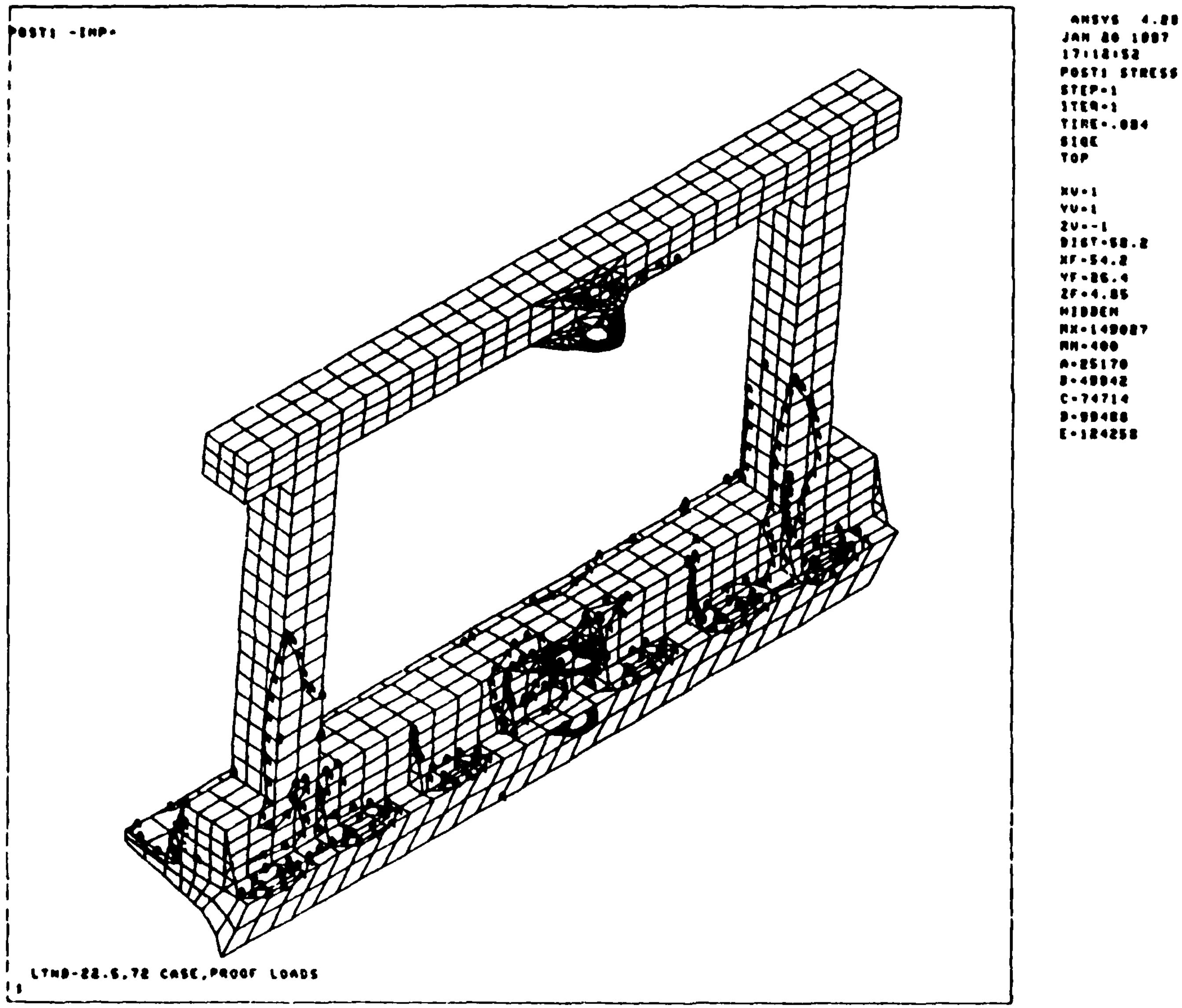
543

(11)



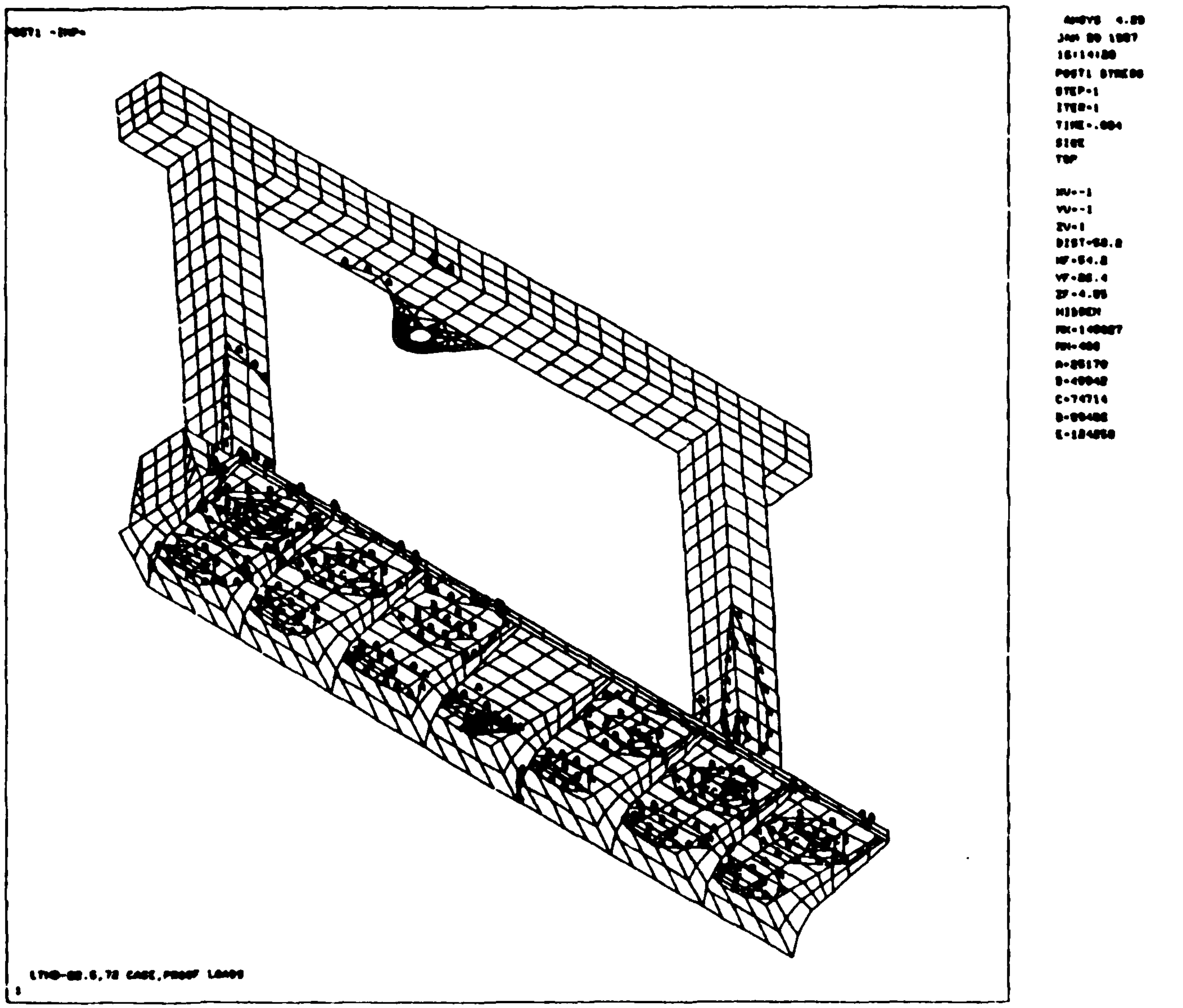
GIMBAL
VERTICAL
BOX BEAMS

544

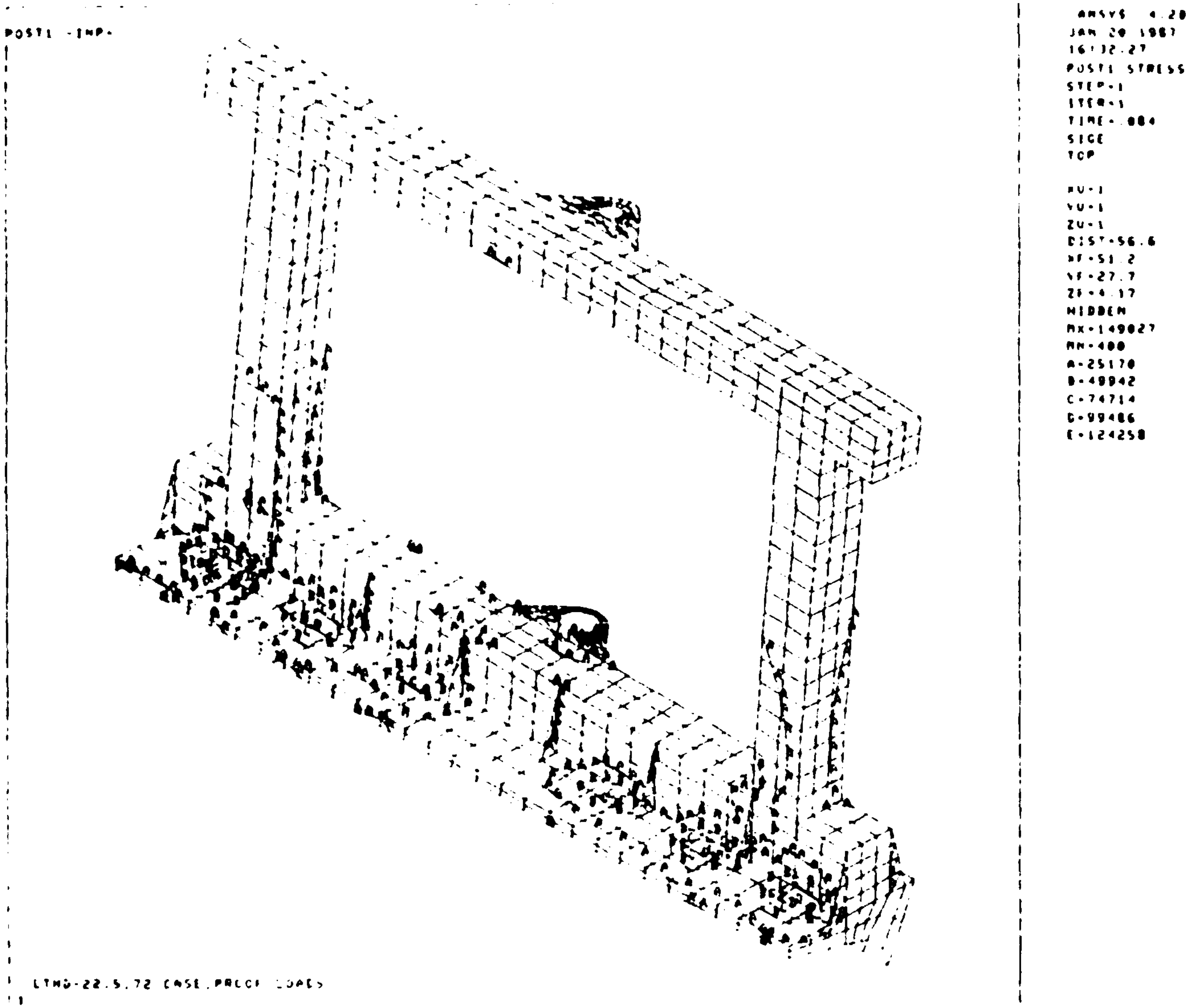

POST1 -INP-
ANSYS 4.2
POST1 STRESS
STEP=1
ITER=1
TIME=.084
SIDE
TOP
XV=1
YV=1
ZV=-1
XF=54.2
YF=26.4
ZF=4.85
HIDDEN
MX=149087
MN=400
A=25170
B=49942
C=74714
D=99486
E=124258
LTMB-22.5.72 CASE,PROOF LOADS

545

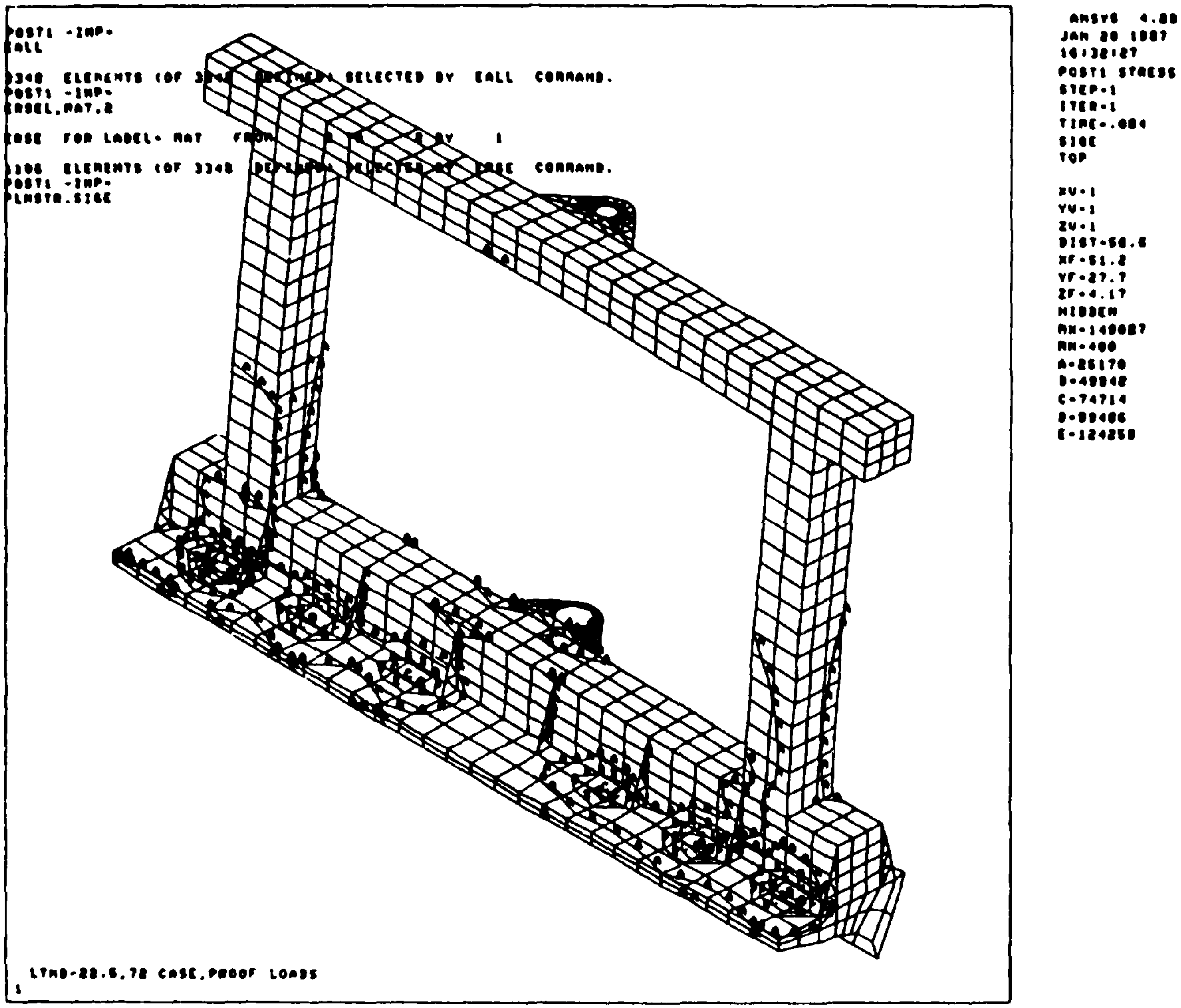
(53)


POST1 STRESS
STEP=1
ITER=1
TIME=.004
SIDE
TOP
XV=-1
YV=-1
ZV=1
HIDDEN
CASE,PROOF LOADS

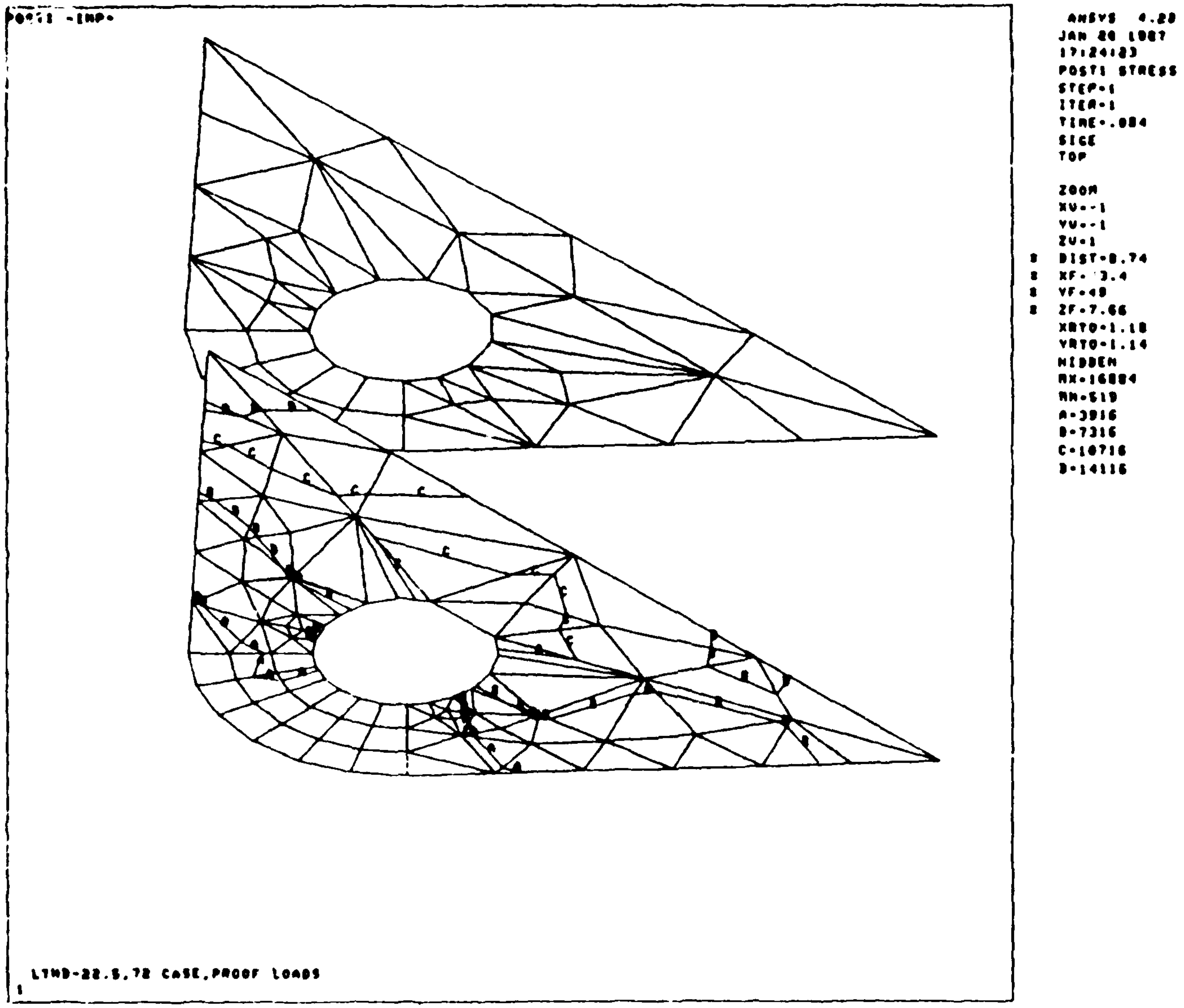
546


POST1 -INP-
ANSYS 4.20
JAN 20 1987
16:32:27
POST1 STRESS
STEP=1
ITER=1
TIME=.084
SIGE
TOP
XV=1
YV=1
ZV=1
DIST=56.6
XF=51.2
YF=27.7
ZF=4.17
HIDDEN
MX=149027
MN=400
A=25170
B=49942
C=74714
D=99486
E=124258
LTHD-22.5.72 CASE,PRECF LOADS

547

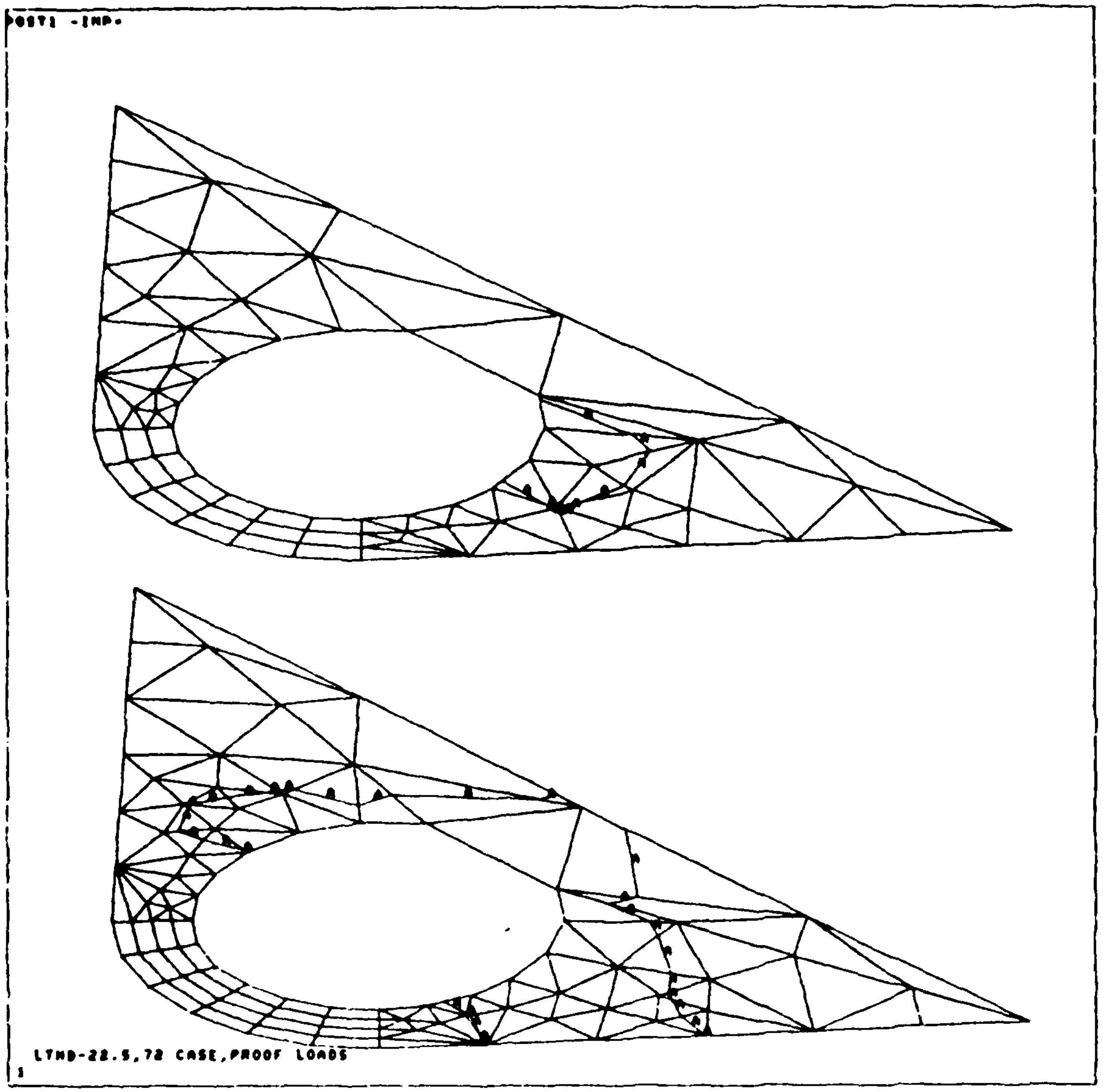

POST1 -INP-
EALL
3348 ELEMENTS (OF 3348 DEFINED) SELECTED BY EALL COMMAND.
POST1 -INP-
ESEL,MAT,2
ESE FOR LABEL= MAT FROM
3106 ELEMENTS (OF 3348 DEFINED) SELECTED BY ESE COMMAND.
POST1 -INP-
PLNSTR,SIGE
LTHD-28.5.78 CASE,PROOF LOADS
ANSYS 4.2B
JAN 20 1987
16:38:27
POST1 STRESS
STEP=1
ITER=1
TIME=.084
SIGE
TOP
XV=1
YV=1
ZV=1
DIST=68.6
XF=51.2
YF=27.7
ZF=4.17
HIDDEN
MX=149087
MN=400
A=25170
B=49942
C=74714
D=99486
E=124258

548


POST1 -INP-
ANSYS 4.2B
JAN 20 1987
17:24:23
POST1 STRESS
STEP=1
ITER=1
TIME=.084
SIGE
TOP
ZOOM
XV=-1
YV=-1
ZV=1
DIST=8.74
XF=13.4
YF=49
ZF=7.66
XRTO=1.18
YRTO=1.14
HIDDEN
MX=16884
MN=519
A=3916
B=7316
C=10716
D=14116
LTHD-22.5,72 CASE,PROOF LOADS

TOP TABS

549

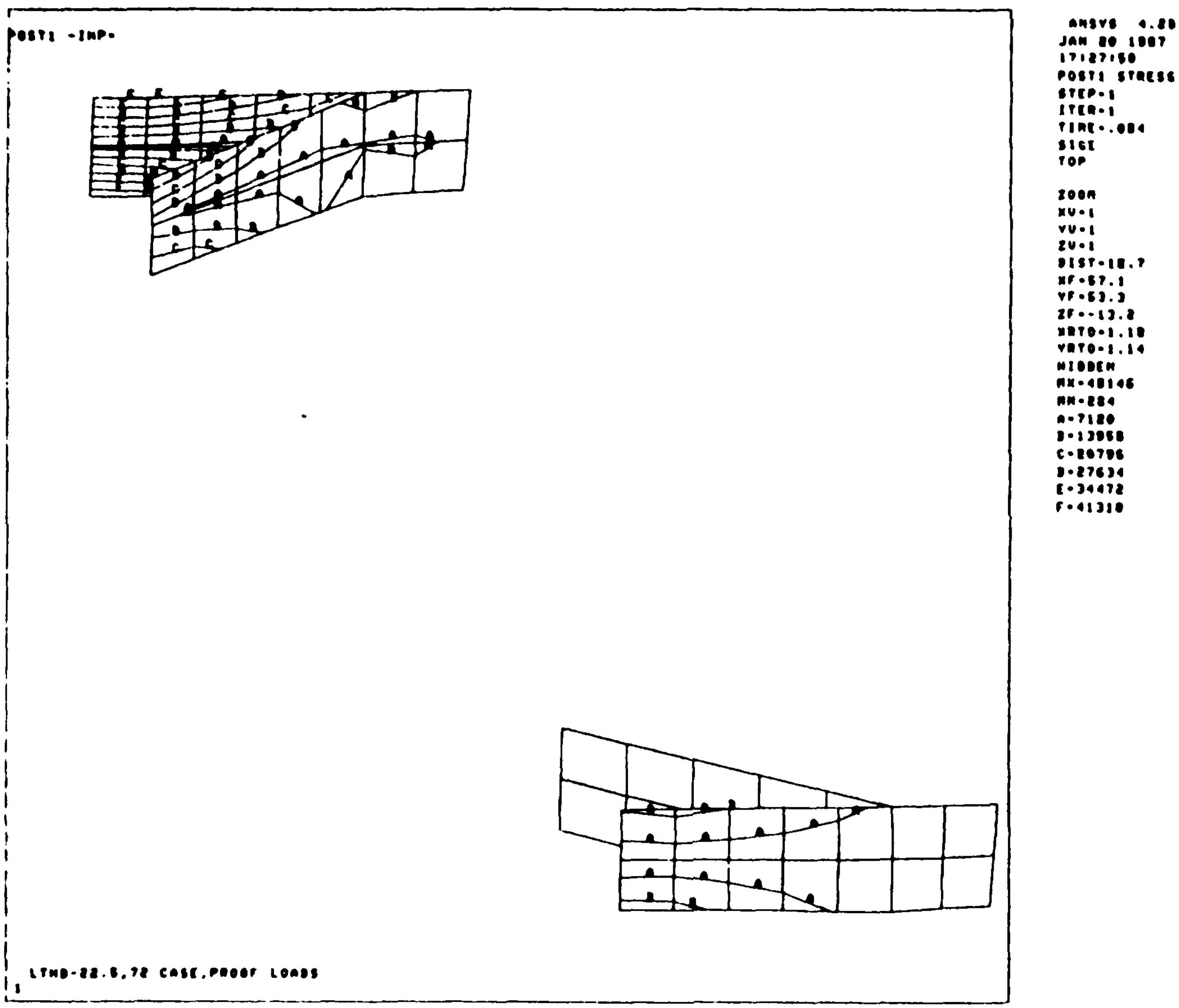


ANSYS 4.2B
JAN 20 1987
17:28:47
POST1 STRESS
STEP=1
ITER=1
TIME=.084
SIGE
TOP

ZOOM
XV=-1
YV=-1
ZV=1
* DIST=7.73
* XF=65.8
* YF=17.6
* ZF=-13.5
XRTO=1.18
HIDDEN
RX=54913
RN=1980
A=27735

BOTTOM
TABS

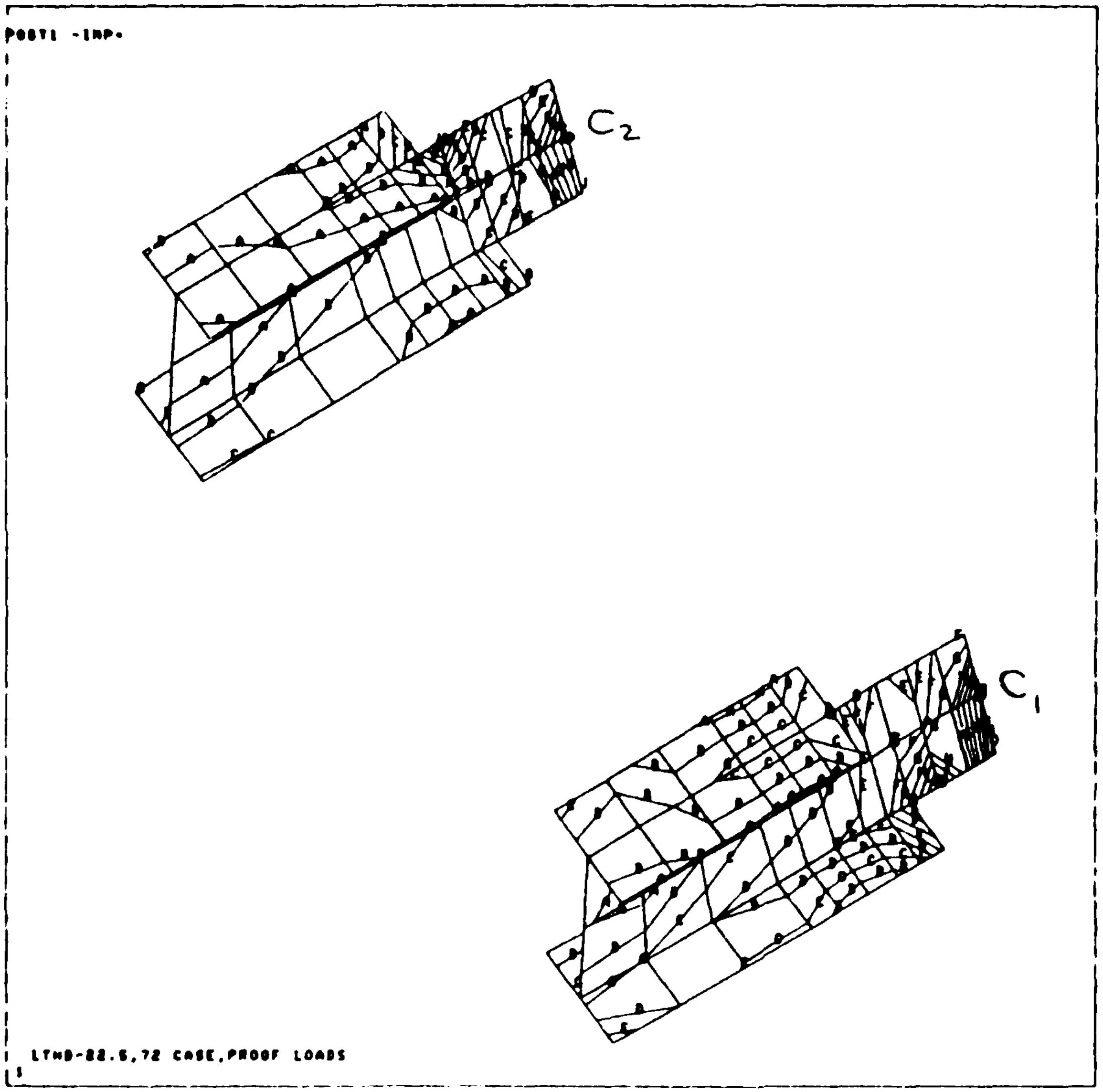
550



TOP ARMS,
GIMBAL

551

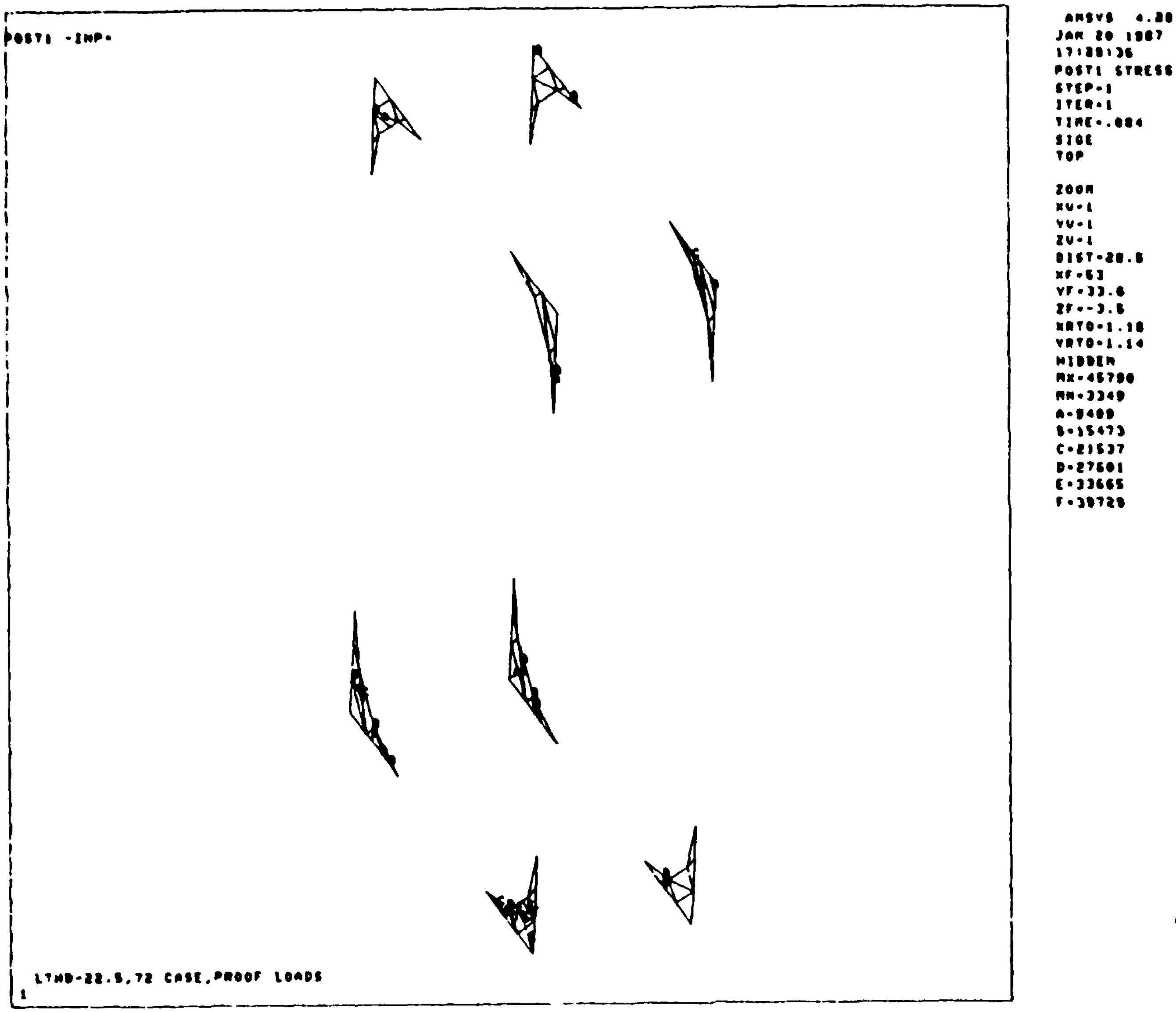
(59)



ANSYS 4.8B
JAN 20 1987
17:26:50
POST1 STRESS
STEP=1
ITER=1
TIME=.004
SIGE
TOP

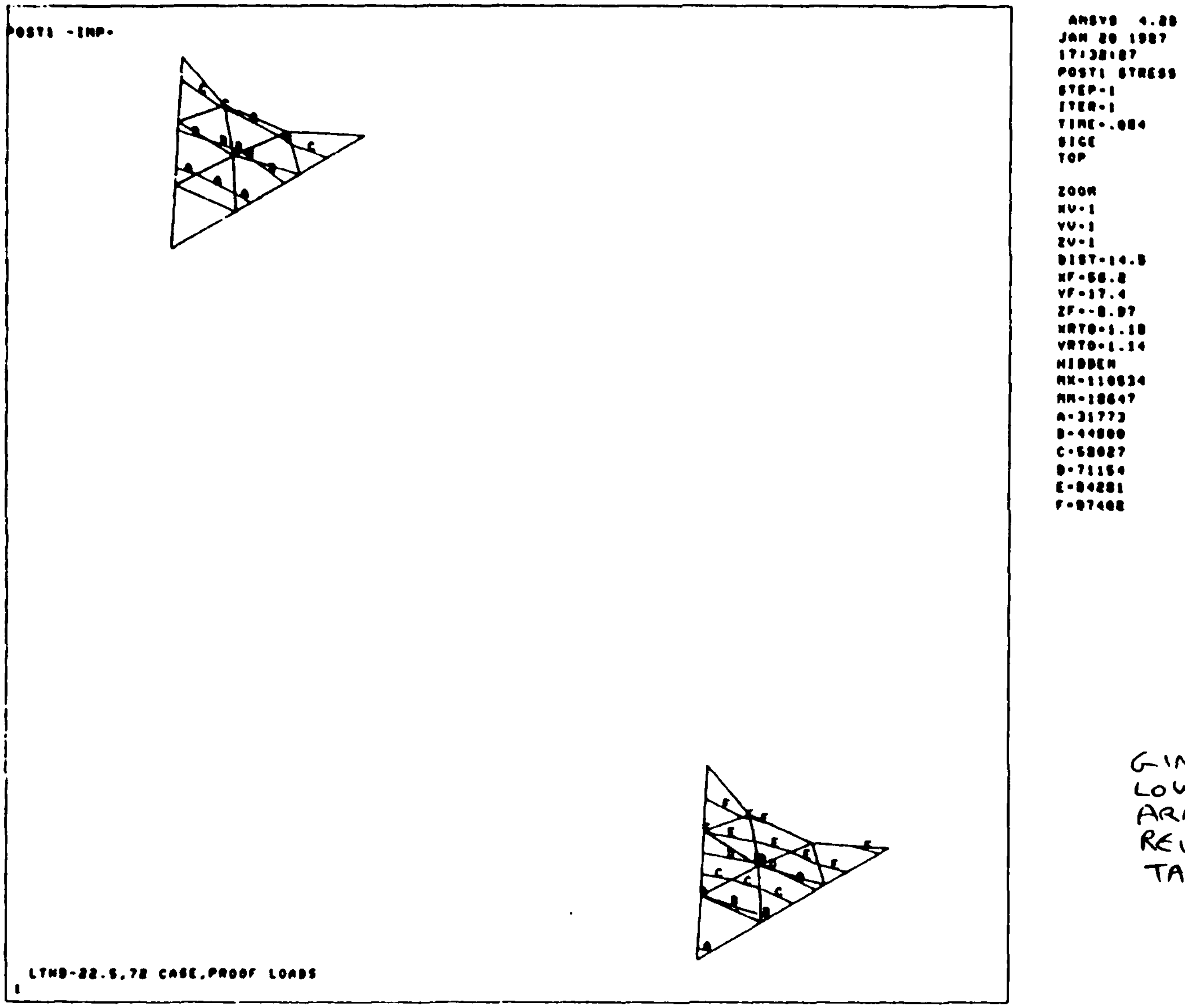
ZOOM
XV=1
YV=1
ZV=1
DIST=20
XF=57.3
YF=14.2
ZF=-12.7
XRTO=1.18
YRTO=1.14
HIDDEN
MX=153556
MN=6250
A=15458
B=24665
C=33872
D=43079
E=52286
F=61493
G=70700
H=79907
I=89114
J=98321
K=107528
L=116735
M=125942
N=135149
O=144356

LOWER
GIMBAL
ARMS



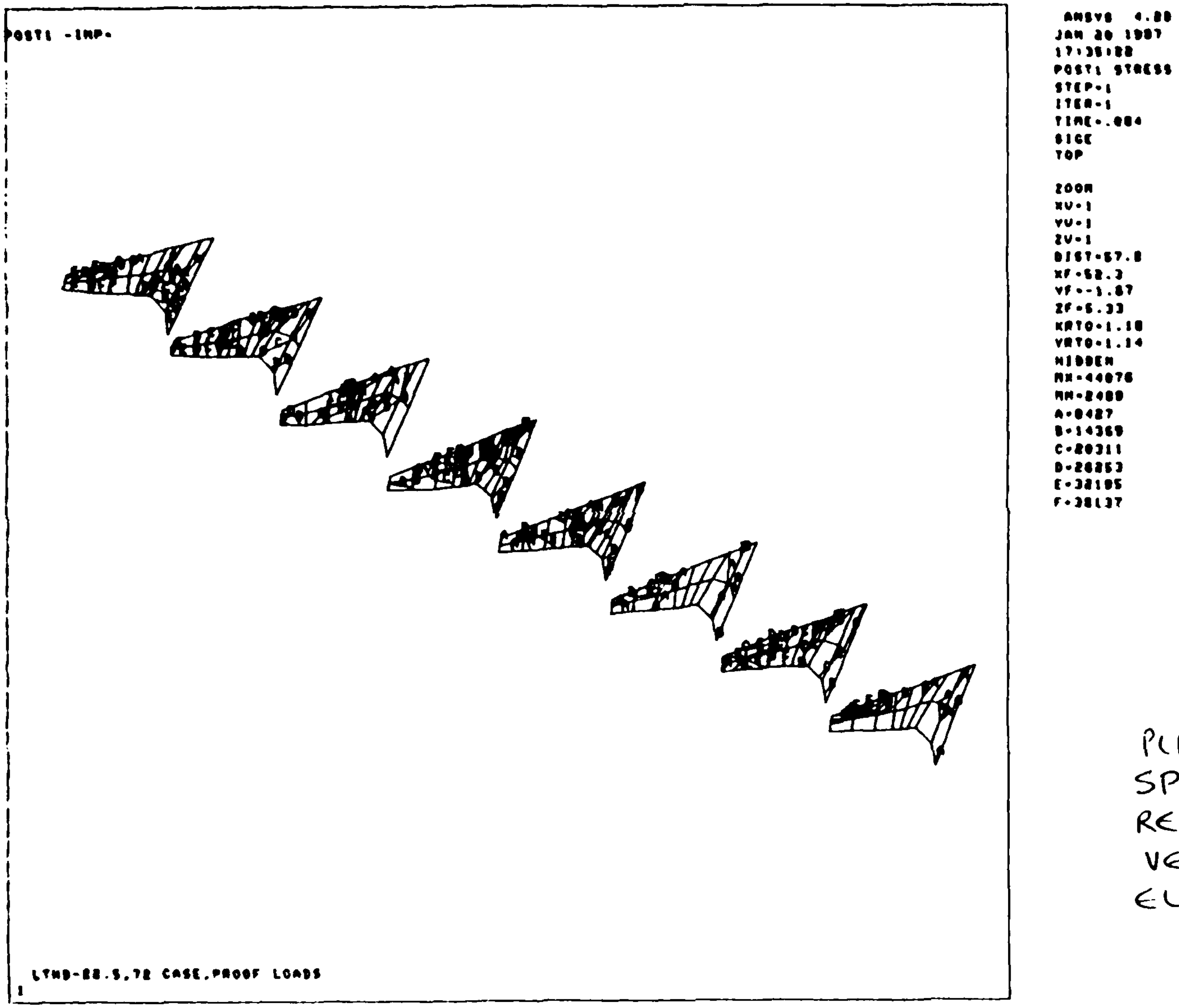
GIMBAL REINFORCING TABS

553



GIMBAL
LOWER
ARM
REINFORCING
TABS

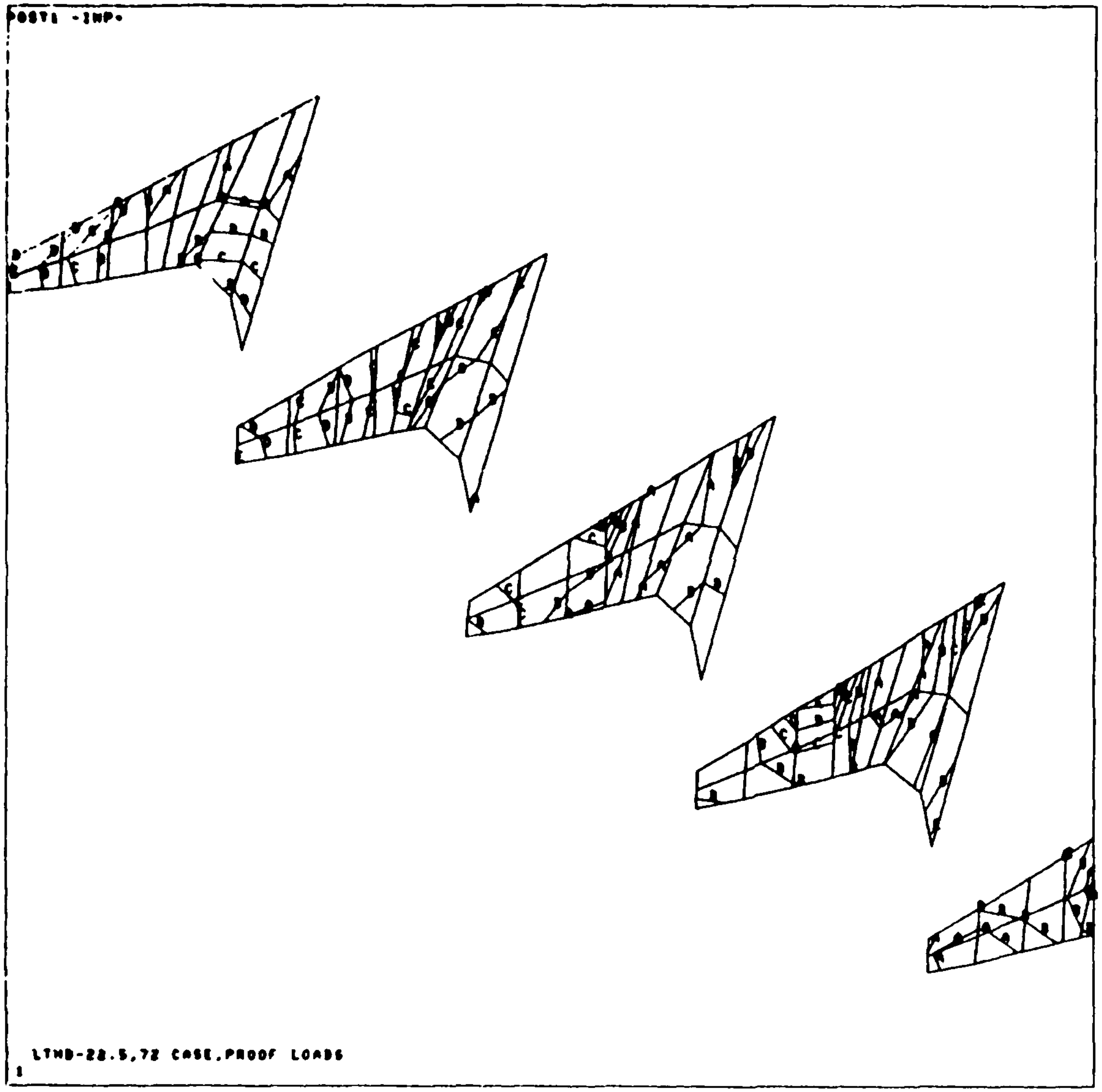
554



PLATFORM
SPADE
REINFORCING—
VERTICAL
ELEMENTS

555

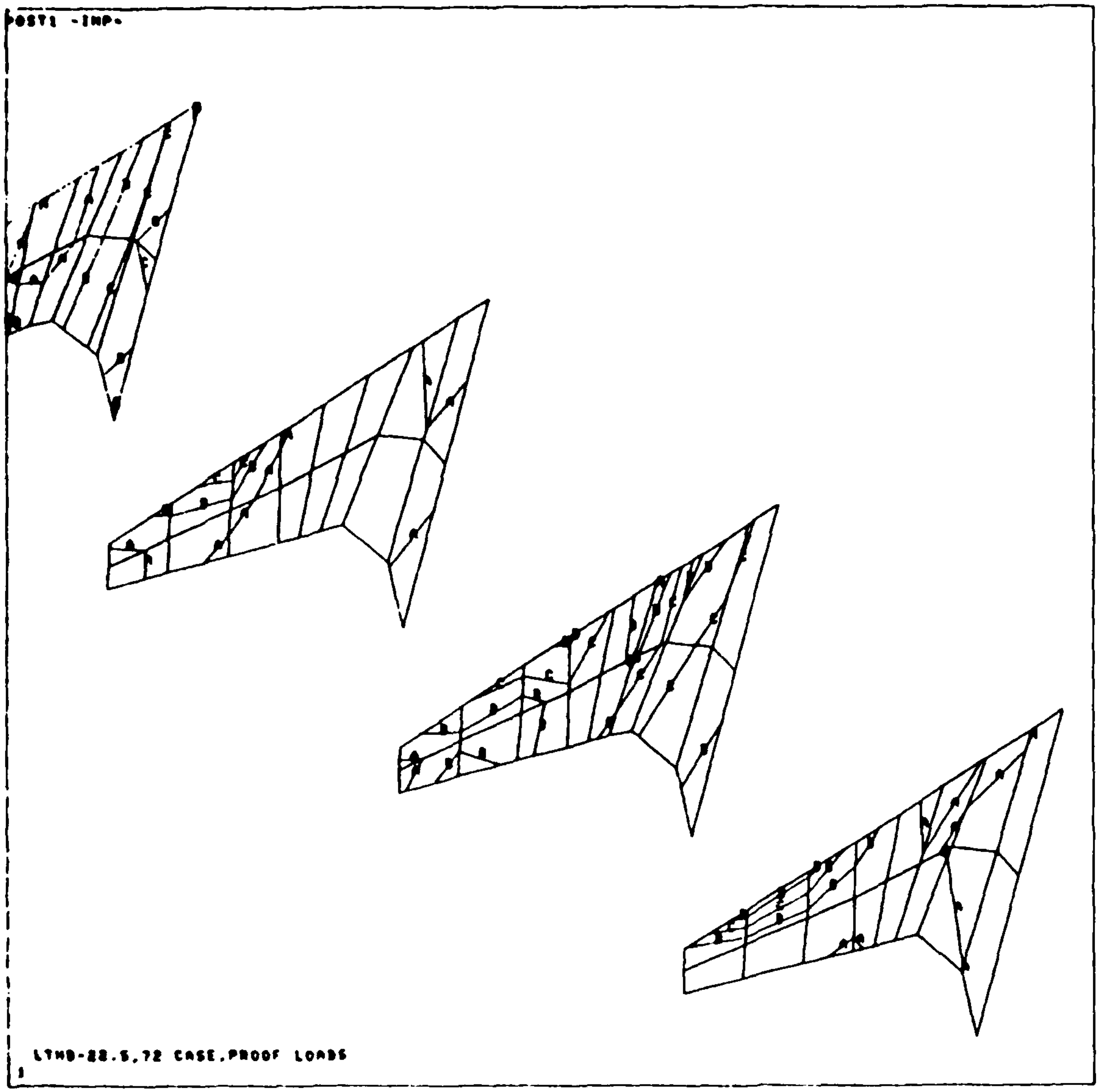
(6/14)



ANSYS 4.2B
JAN 20 1987
17:36:33
POST1 STRESS
STEP=1
ITER=1
TIME=.004
SIDE
TOP

ZOOM
XV=1
YV=1
ZV=1
* DIST=40.8
* XF=35.1
* YF=6.11
* ZF=14.8
XRTO=1.05
YRTO=2.4
HIDDEN
MX=44078
MN=0
A=9418
B=16350
C=23282
D=30214
E=37146

556

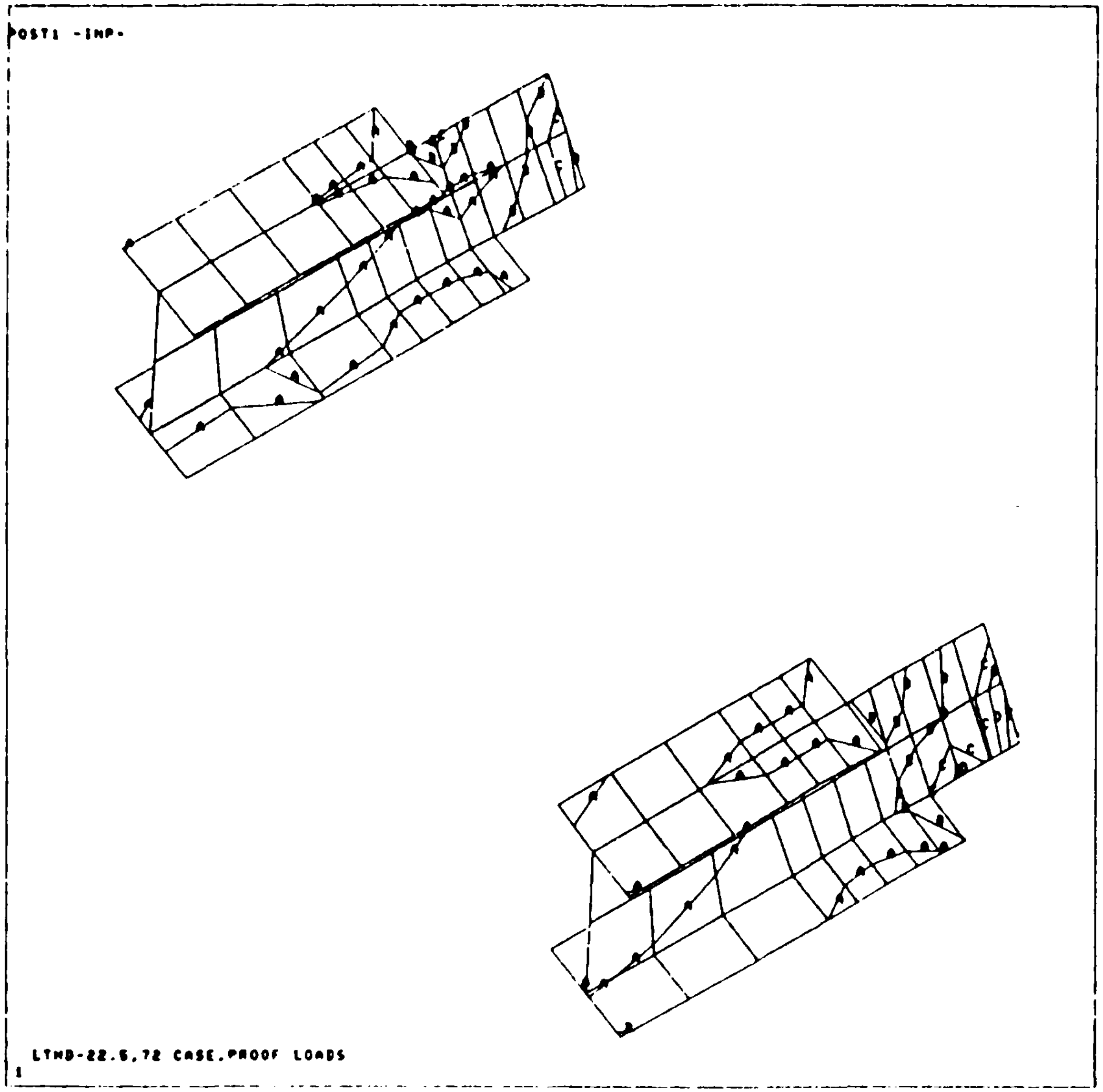


ANSYS 4.2B
JAN 20 1987
17:37:21
POST1 STRESS
STEP=1
ITER=1
TIME=.084
SIGE
TOP

ZOOM
XV=1
YV=1
ZV=1
* DIST=38.4
* XF=75.4
* YF=-11.8
* ZF=-8.17
XRTO=1.05
YRTO=2.41
HIDDEN
MX=38179
MN=2489
A=9418
B=16350
C=23282
D=30214
E=37146

557

(65)

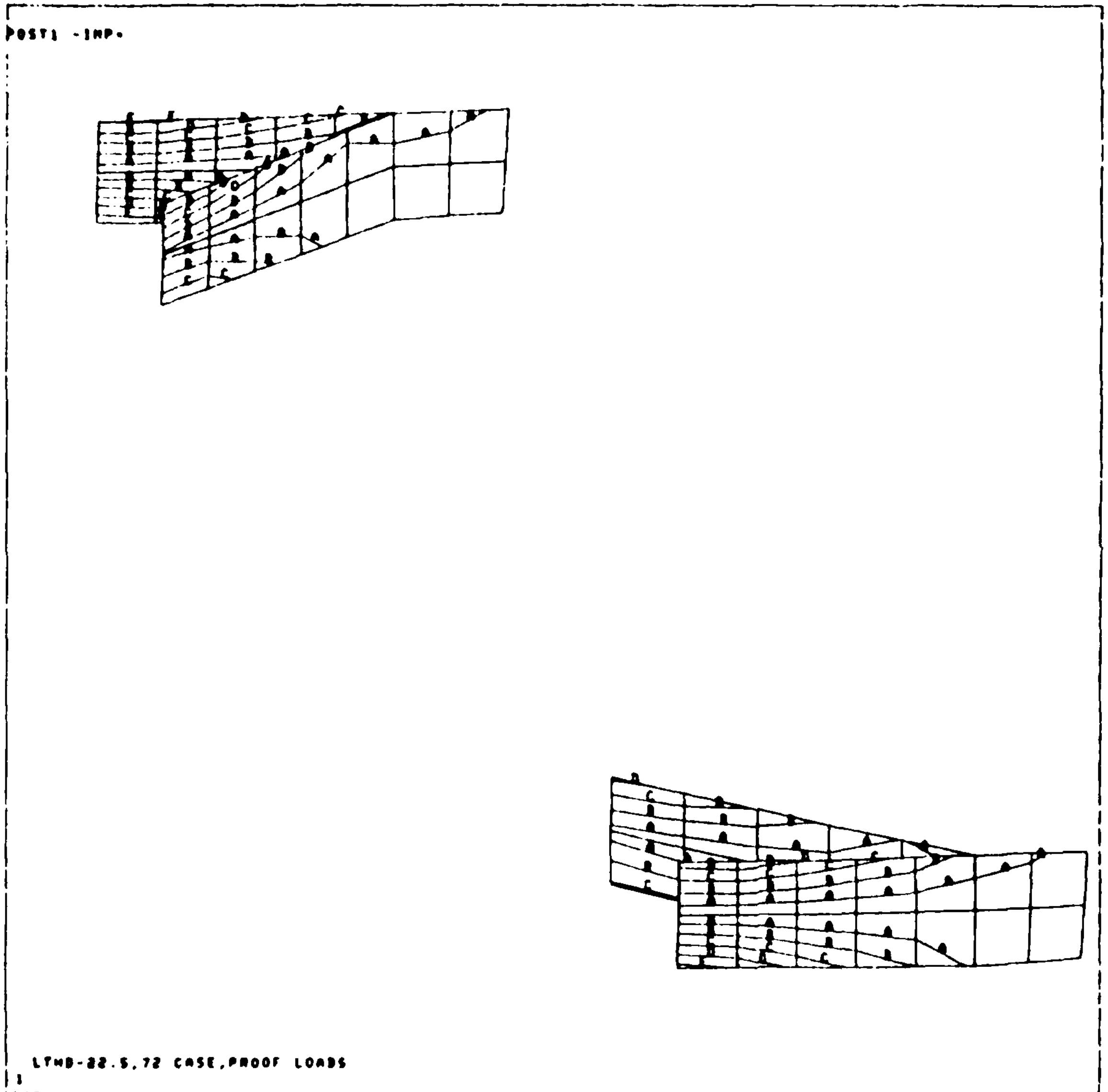


ANSYS 4.2B
JAN 21 1987
11:03:10
POST1 STRESS
STEP=1
ITER=1
TIME=.237
SIDE
TOP

ZOOM
XV=1
YV=1
ZV=1
DIST=21
XF=57.3
YF=14.2
ZF=-12.7
XRTO=1.3
YRTO=1.2
HIDDEN
MX=76539
MN=4261
A=16306
B=28353
C=40400
D=52447
E=64494

LOWER
GIMBAL
ARMS

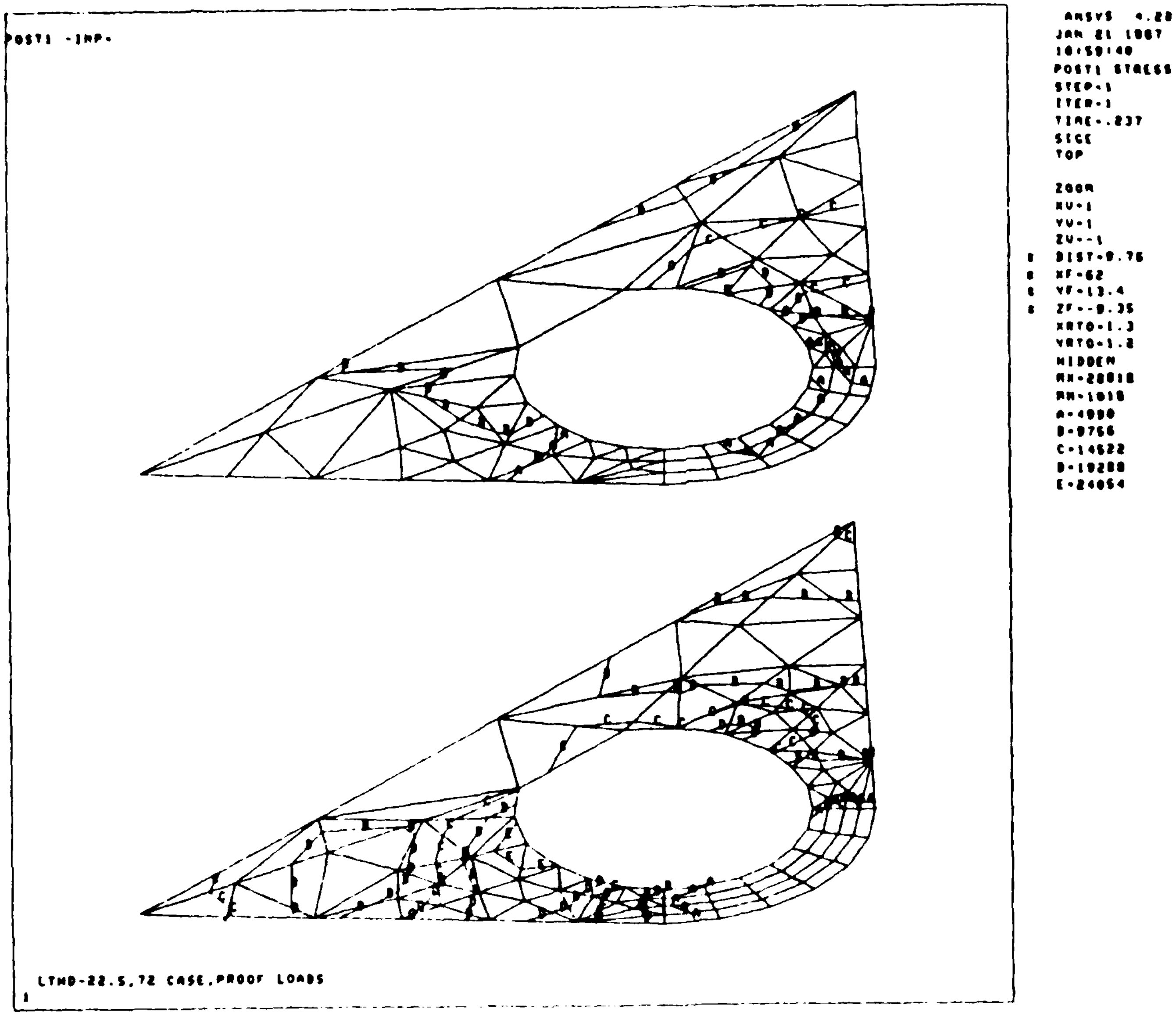
560



ANSYS 4.2B
JAN 21 1987
11:02:22
POST1 STRESS
STEP=1
ITER=1
TIME=.237
SIDE
TOP

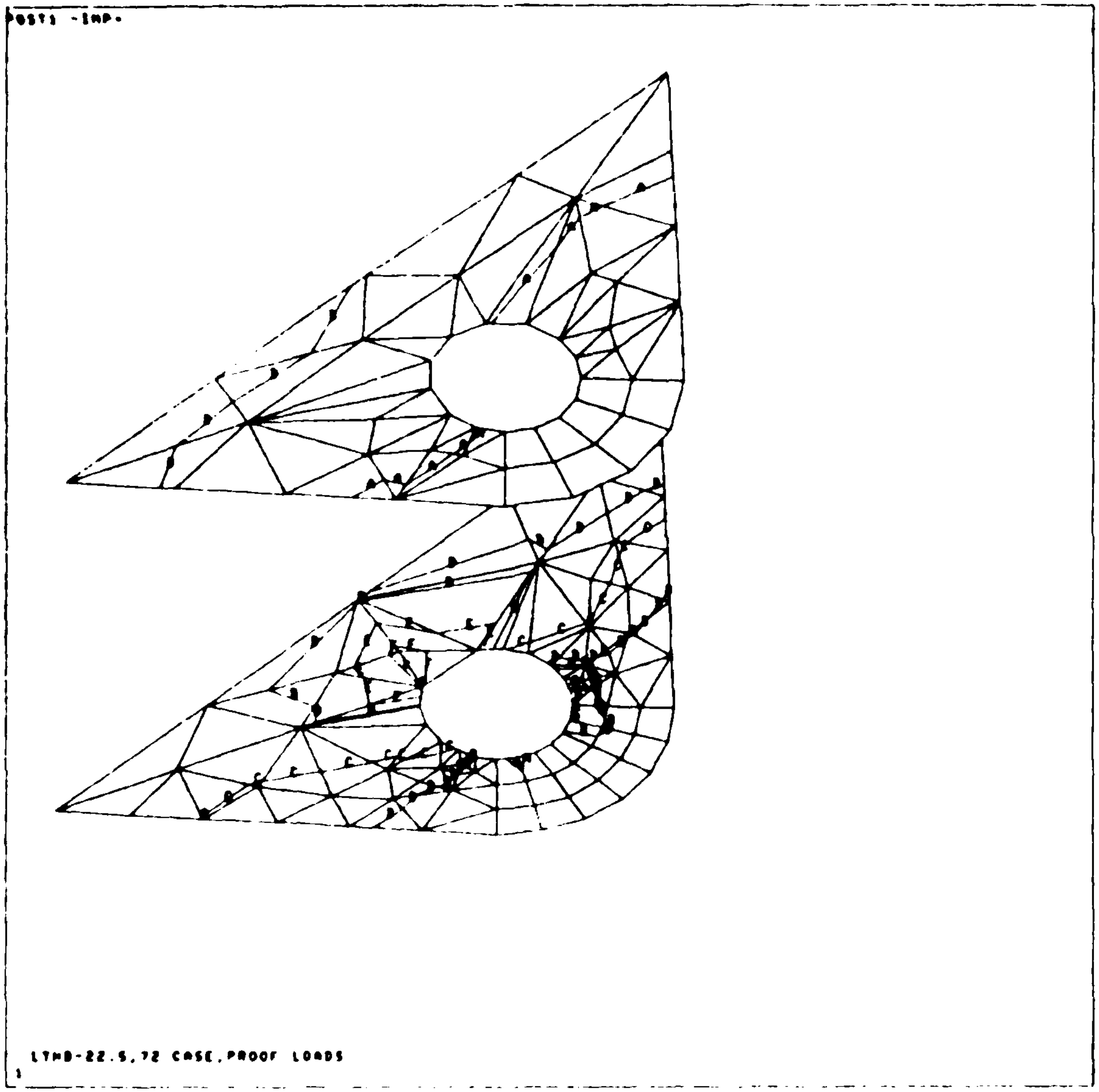
ZOOM
XV=1
YV=1
ZV=1
DIST=20.6
XF=57.1
YF=53.3
ZF=-13.2
XRTO=1.3
YRTO=1.2
HIDDEN
MX=101923
MN=8401
A=23986
B=39574
C=55162
D=70750
E=86338

TOP
GIMBAL
ARMS



BOTTOM
TABS
562

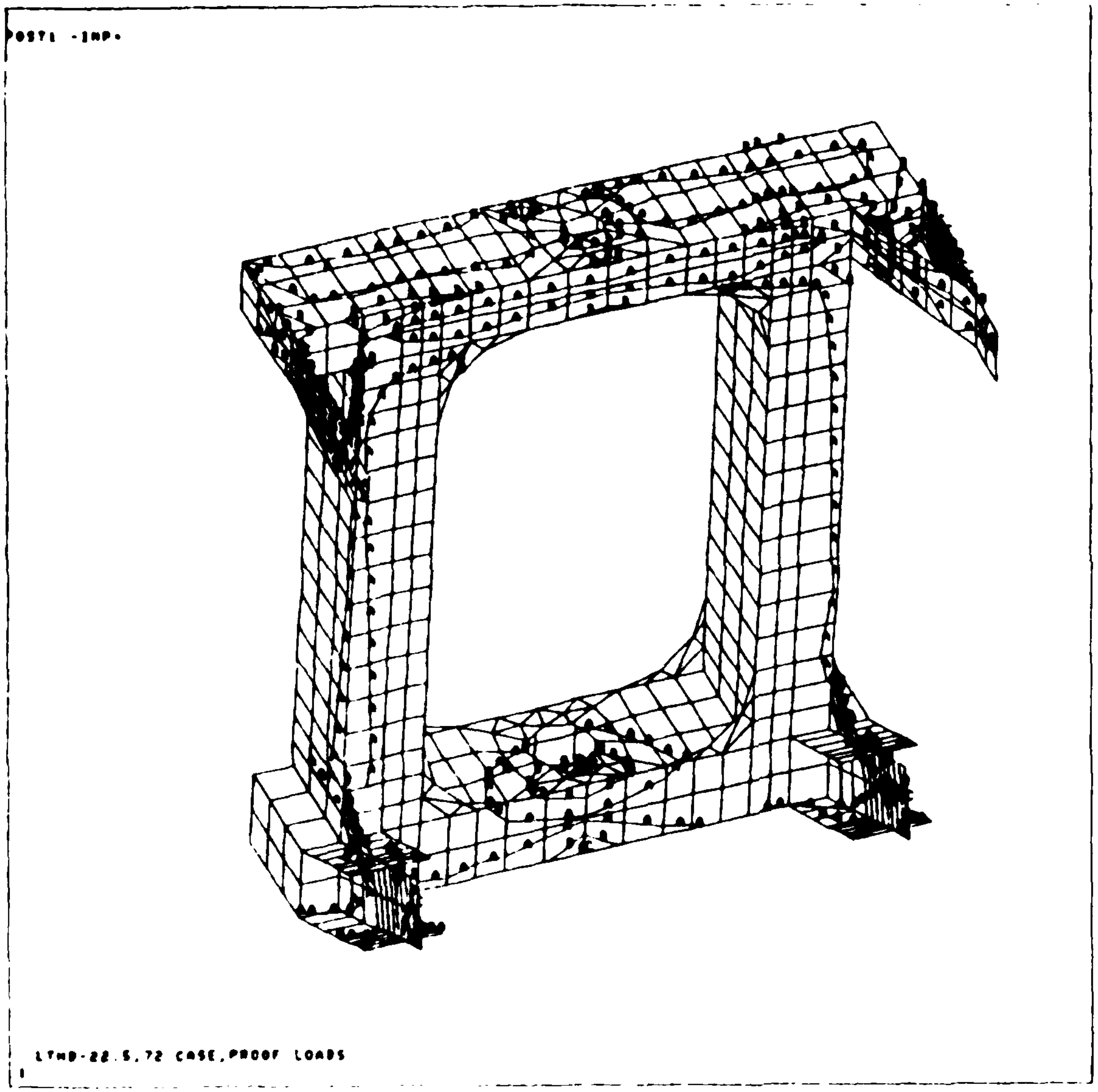
(68



ANSYS 4.2B
JAN 21 1987
10:54:04
POST1 STRESS
STEP=1
ITER=1
TIME=.237
SIGE
TOP

ZOOM
XV=1
YV=1
ZV=-1
DIST=8.72
XF=41
YF=48.1
ZF=4.44
VRTO=1.2
HIDDEN
MX=11016
MN=227
A=2013
B=3800
C=5587
D=7374
E=9161
F=10948

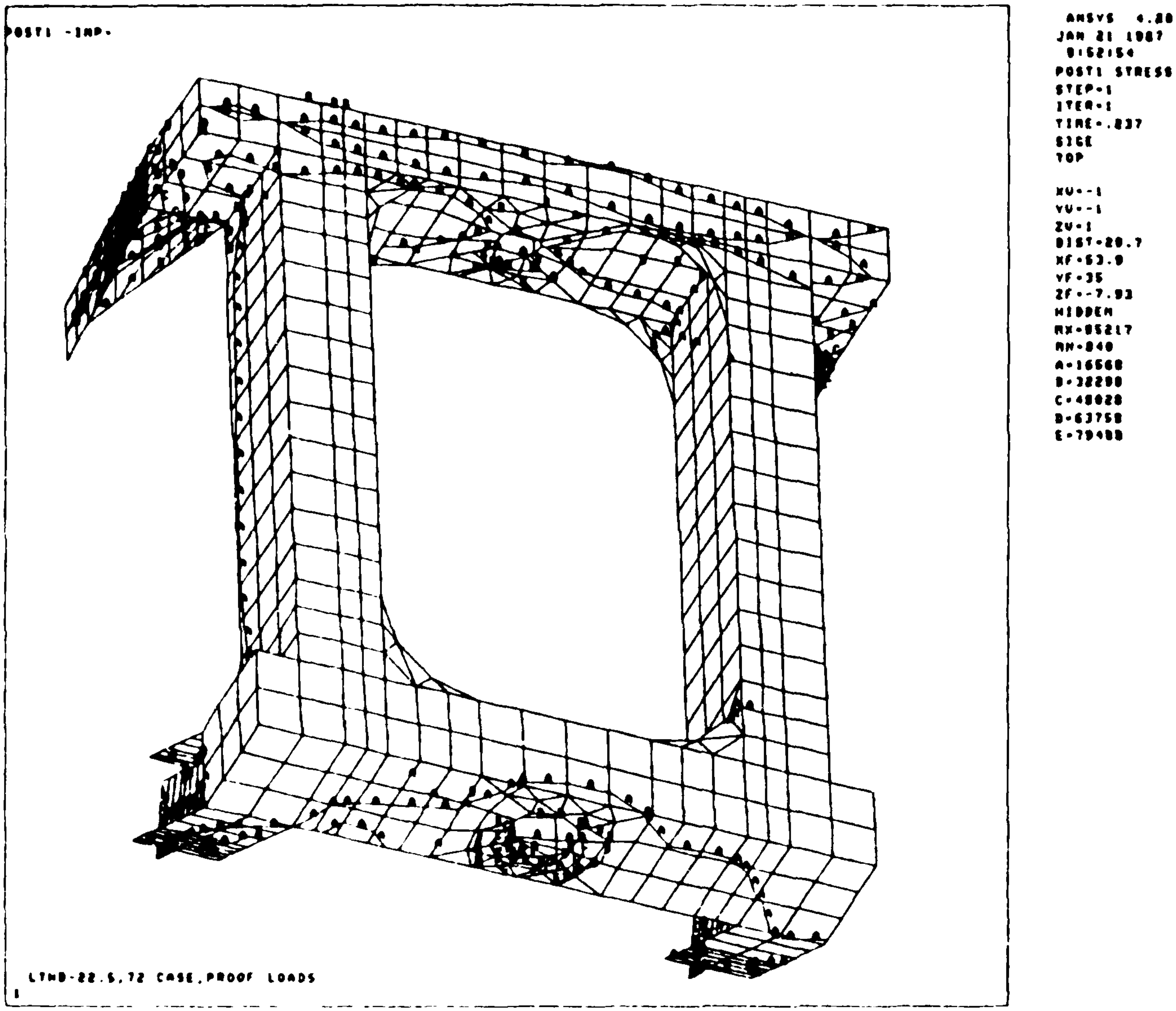
TOP
TABS



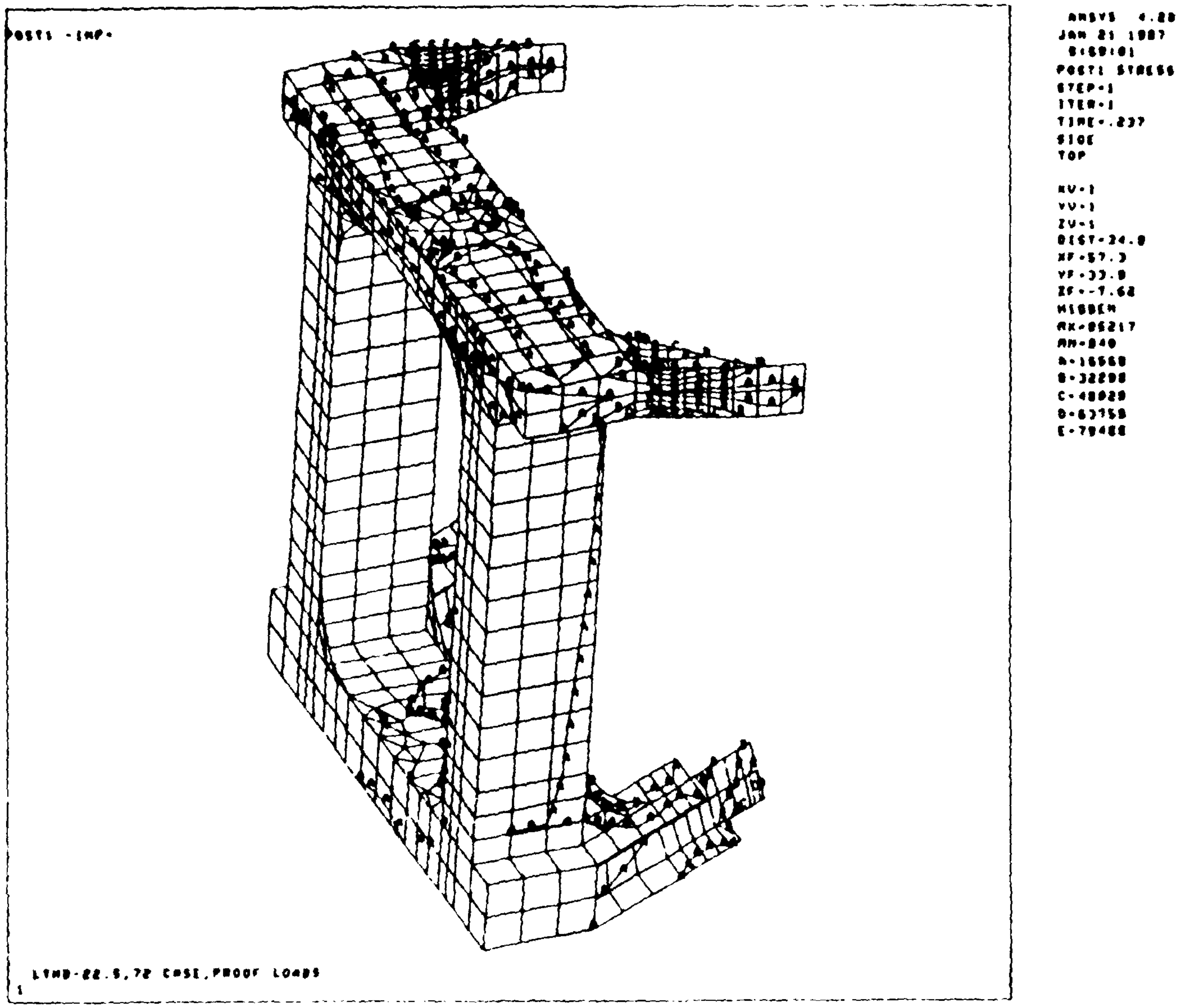
ANSYS 4.2B
JAN 21 1987
10:30:15
POST1 STRESS
STEP=1
ITER=1
TIME=.237
SIGE
TOP

XV=1
YV=1
ZV=-1
DIST=34.0
XF=67.3
YF=33.0
ZF=-7.62
HIDDEN
MX=95217
MN=840
A=16560
B=32280
C=48020
D=63750
E=79480

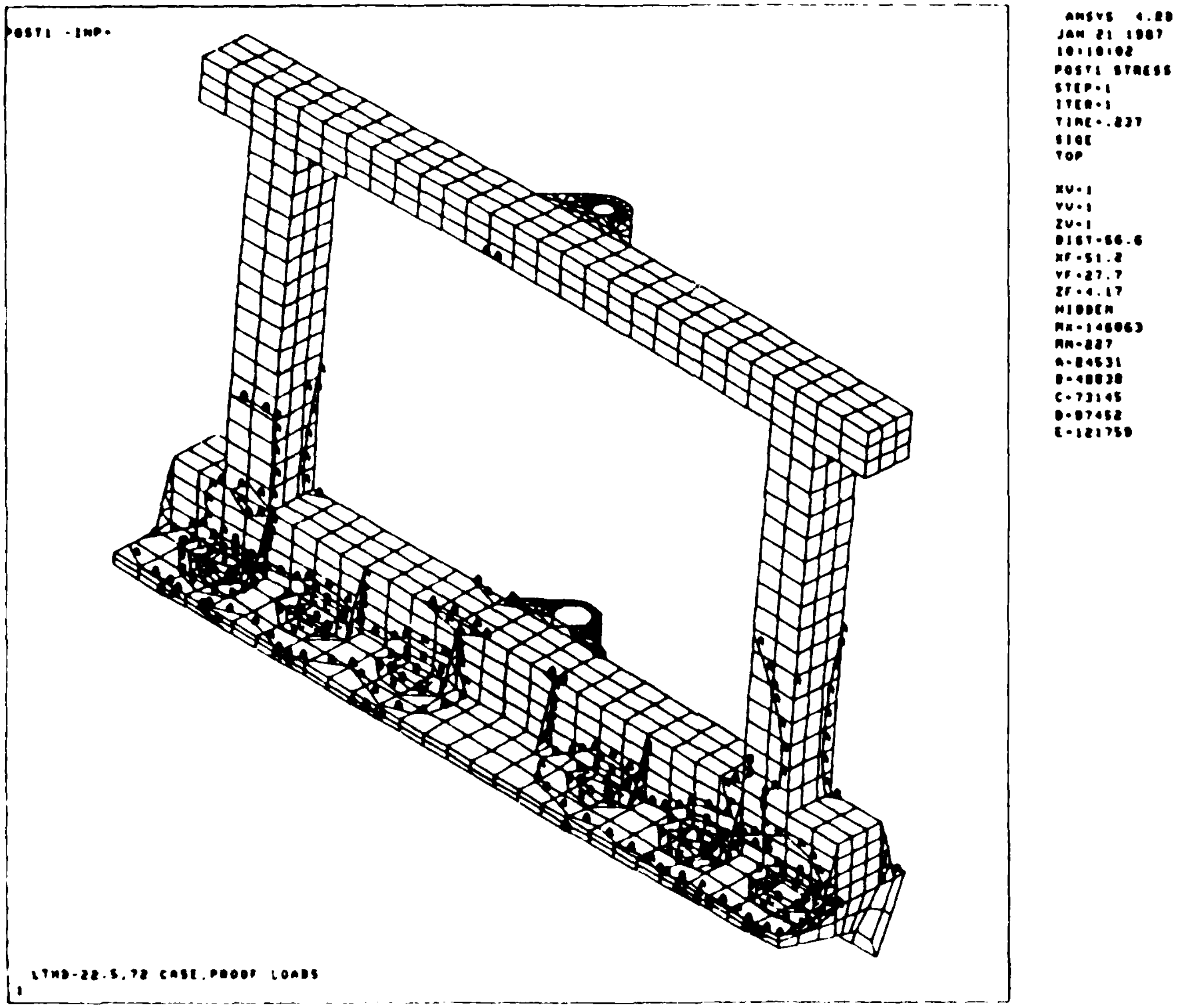
564

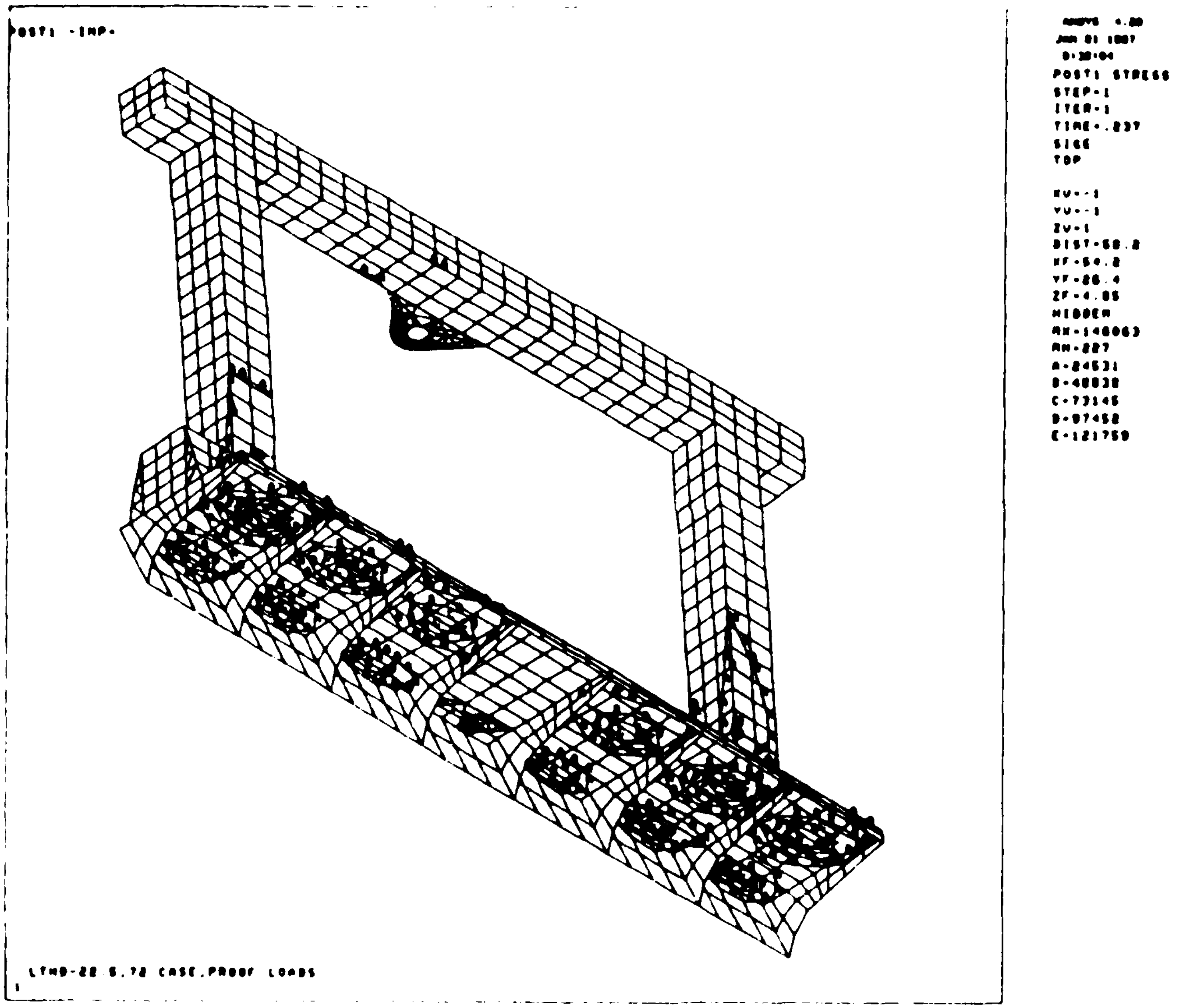

POST1 -INP-
LTHD-22.5,72 CASE,PROOF LOADS
1
ANSYS 4.2B
JAN 21 1987
8:52:54
POST1 STRESS
STEP=1
ITER=1
TIME=.237
SIGE
TOP
XV=-1
YV=-1
ZV=1
DIST=28.7
XF=53.9
YF=35
ZF=-7.93
HIDDEN
MX=85217
MN=840
A=16568
B=32298
C=48028
D=63758
E=79488

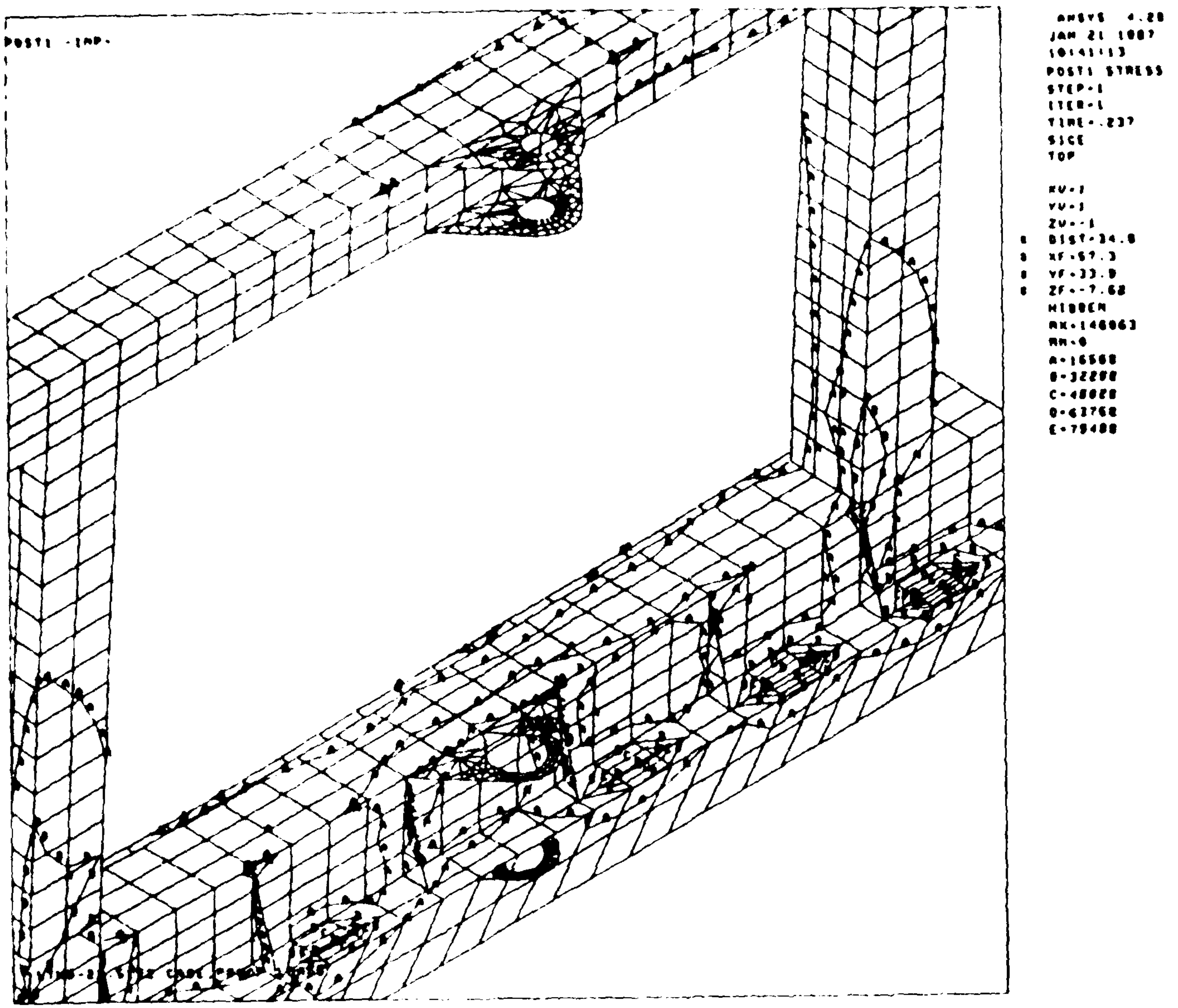
565

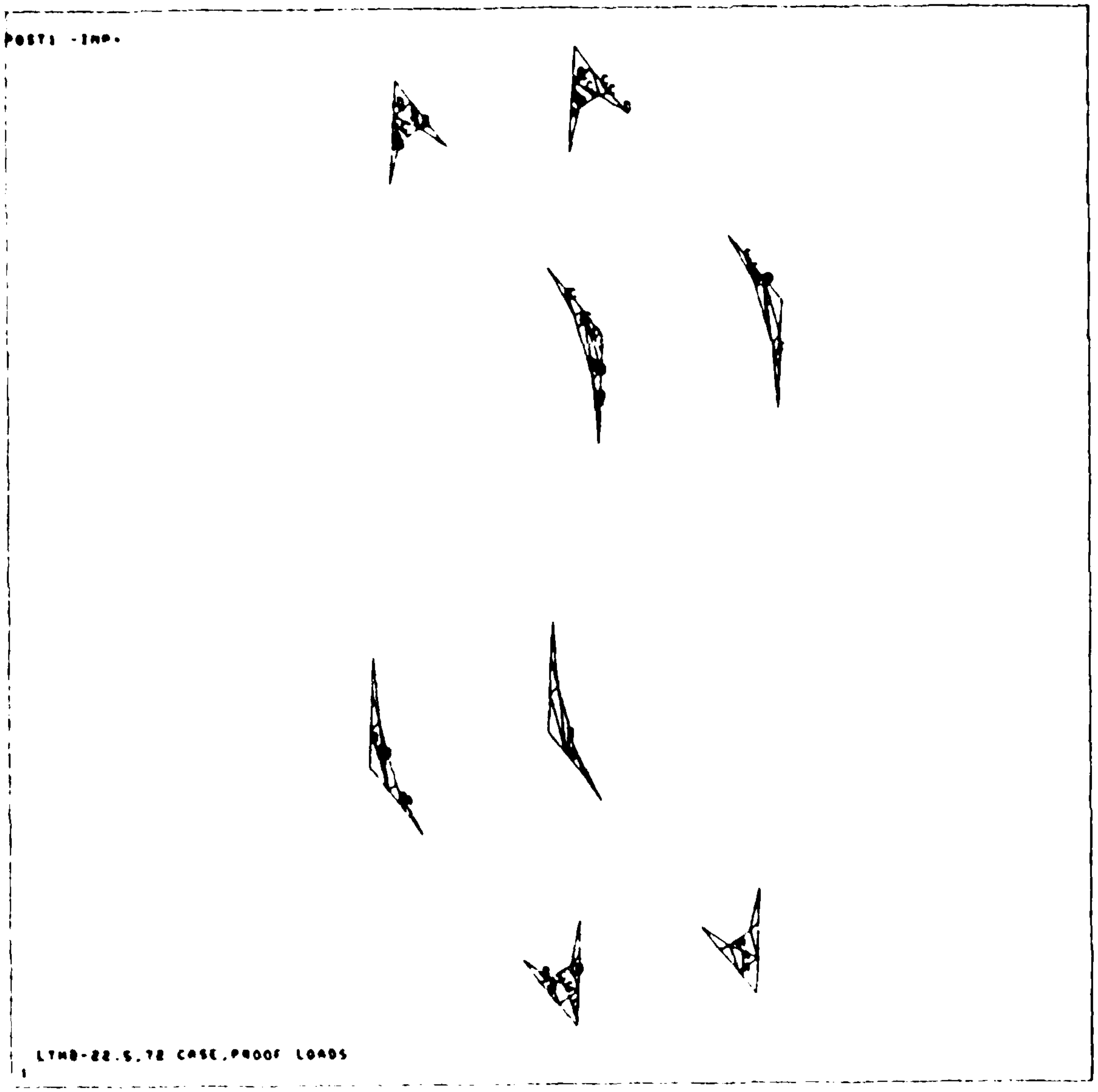

POST1 -INP-
LYND-22.5,72 CASE,PROOF LOADS
1
ANSYS 4.2A
JAN 21 1987
9:59:01
POST1 STRESS
STEP=1
ITER=1
TIME=.237
SIDE
TOP
XV=1
YV=1
ZV=1
DIST=24.8
XF=57.3
YF=33.8
ZF=-7.62
HIDDEN
MX=85217
MN=840
A=16560
B=32290
C=48020
D=63750
E=79480

566


POST1 -INP-
LTHD-22.5.72 CASE.PROOF LOADS
1
ANSYS 4.2B
JAN 21 1987
10:10:02
POST1 STRESS
STEP=1
ITER=1
TIME=.237
SIDE
TOP
XV=1
YV=1
ZV=1
DIST=66.6
XF=51.2
YF=27.7
ZF=4.17
HIDDEN
MX=146063
MN=237
A=24531
B=48838
C=73145
D=97452
E=121759


POST1 STRESS
STEP=1
ITER=1
SIGE
TOP
XV=-1
YV=-1
ZV=1
HIDDEN
CASE,PROOF LOADS


POST1 -INP-
ANSYS 4.2B
JAN 21 1987
10:41:13
POST1 STRESS
STEP=1
ITER=1
TIME=.237
SIDE
TOP
XV=1
YV=1
ZV=-1
DIST=34.8
XF=57.3
YF=33.9
ZF=-7.68
HIDDEN
MX=146063
MN=0
A=16500
B=32200
C=48020
D=63750
E=79480



ANSYS 4.2B
JAN 21 1987
11:04:11
POST1 STRESS
STEP=1
ITER=1
TIME=.837
SIGE
TOP

ZOOM
XV=1
YV=1
ZV=1
DIST=30
XF=53
YF=33.6
ZF=-3.5
XRTO=1.3
YRTO=1.2
HIDDEN
MX=24079
MN=2435
A=6041
B=9649
C=13257
D=16865
E=20473

570

(21)

0.237 sec

3158	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3159	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3160	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

***** POST1 ELEMENT STRESS LISTING *****

LOAD STEP 1 ITERATION= 1 SECTION= 1
TIME= 0.23700 LOAD CASE= 1

ELEM	SDIR	SDZ	SDY1	SDZ2	SDY2
3161	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3162	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3163	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3164	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3165	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3166	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3167	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3168	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3169	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3170	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3171	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3172	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3173	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3174	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

***** POST1 ELEMENT STRESS LISTING *****

LOAD STEP 1 ITERATION= 1 SECTION= 1
TIME= 0.23700 LOAD CASE= 1

ELEM	SDIR	SDZ	SDY1	SDZ2	SDY2
3175	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3176	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3177	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3178	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3179	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3180	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3181	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3182	-883.53	-8965.5	1300.5	18934.	1888.1
3183	-1000.1	82215.	7751.6	80510.	5863.5
3184	352.80	32018.	7008.7	-7500.4	-3507.8
3185	320.89	596.89	-974.99	0.15647E-08	-448.07
3186	-157.57	1894.1	-1737.8	-0.74048E-08	-843.55
3187	864.80	-20.904	311.28	0.95788E-03	99.570
3188	62.573	-886.62	90.295	0.24844E-03	81.018

***** POST1 ELEMENT STRESS LISTING *****

LOAD STEP 1 ITERATION= 1 SECTION= 1
TIME= 0.23700 LOAD CASE= 1

ELEM	SDIR	SDZ	SDY1	SDZ2	SDY2
3189	-270.50	710.72	710.09	0.19896E-08	443.75
3190	806.70	573.29	369.95	-0.75004E-03	65.490
3191	107.82	340.05	-484.03	0.40857E-03	-155.31
3192	15.906	279.44	259.17	0.25868E-03	30.041
3193	61.789	2007.3	1372.7	0.25911E-01	644.08
3194	100.90	1828.0	170.82	0.30447E-01	52.318
3195	317.70	1367.8	-695.55	0.38329E-01	-382.70
3196	273.73	634.00	-2080.7	0.84100E-01	-1268.3
3197	824.73	1487.2	2015.4	0.40155E-01	824.74
3198	373.10	1962.1	304.78	0.36011E-01	104.30
3199	107.10	2321.5	-445.05	0.34580E-01	-172.42
3200	38.082	8870.3	-1954.4	0.22871E-01	-844.50
3201	-111.54	-986.83	-650.00	-0.15208E-01	-304.38
3202	-70.701	-1700.4	-2606.8	-0.18286E-01	-1135.5

***** POST1 ELEMENT STRESS LISTING *****

LOAD STEP 1 ITERATION= 1 SECTION= 1
TIME= 0.23700 LOAD CASE= 1

ELEM	SDIR	SDZ	SDY1	SDZ2	SDY2
3203	-980.86	2168.3	1760.3	-0.48173E-08	718.10
3204	-483.09	-830.05	383.48	0.68910E-08	161.59
3205	-180.88	-819.87	-401.01	0.73400E-08	-153.55
	8.371 -10738	94. 78.34	-38.58	-0.55	-.03277E-04 .0591 !
3253	-1310.0	0.8771	-0.3187	0.60000E-05	-0.85000E-01
3254	9878.4	-110.11	-19.008	-0.10200E-03	1.7034
3255	400.27	-30.000	93.014	-0.14084E-03	26.713
3256	-368.95	-86.908	14.616	-0.14031E-08	10.561
3257	2301.0	-18.141	79.991	-0.05382E-03	30.591
3258	-3031.1	-0.0300	41.208	-0.42040E-03	16.004
3259	-1000.0	-73.540	-11.037	-0.63078E-03	-5.1755

***** POST1 ELEMENT STRESS LISTING *****

LOAD STEP 1 ITERATION= 1 SECTION= 1
TIME= 0.23700 LOAD CASE= 1

ELEM	SDIR	SDZ	SDY1	SDZ2	SDY2
3260	768.36	-831.86	6.4867	-0.10723E-08	1.4420
3261	3580.0	-90.977	57.037	-0.80000E-03	10.680
3262	6000.8	-0.8044	10.118	1.0664	-1.4034
3302	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3303	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3309	-0.35540	777.57	0.00000E+00	11635.	0.00000E+00
3310	-0.57080	100.03	0.00000E+00	8420.0	0.00000E+00
3317	0.13303	-1311.4	0.00000E+00	1307.8	0.00000E+00
3318	0.13170	-1877.8	0.00000E+00	1628.8	0.00000E+00
3320	-1.6670	78.062	0.00000E+00	-19.000	0.00000E+00
3321	-3.8848	80.980	0.00000E+00	-873.03	0.00000E+00
3322	1.1105	-8.7471	0.00000E+00	51.880	0.00000E+00
3323	1.7084	668.63	0.00000E+00	-1440.0	0.00000E+00
3324	0.38367	-1740.5	0.00000E+00	1340.9	0.00000E+00

***** POST1 ELEMENT STRESS LISTING *****

LOAD STEP 1 ITERATION= 1 SECTION= 1
TIME= 0.23700 LOAD CASE= 1

ELEM	SDIR	SDZ	SDY1	SDZ2	SDY2
3325	0.38483	-1302.5	0.00000E+00	1850.9	0.00000E+00
3326	-0.17100E-01	44.416	0.00000E+00	0.3440	0.00000E+00
3327	0.50311	7816.3	0.00000E+00	-582.77	0.00000E+00
3328	0.50311	-582.77	0.00000E+00	-8061.0	0.00000E+00
3329	0.73303E-10	-0.60010E-08	0.00000E+00	0.14070E-08	0.00000E+00
3330	-1.0000	44.367	0.00000E+00	4.7653	0.00000E+00
3331	-0.87059	47.783	0.00000E+00	-4.7940	0.00000E+00
3332	-0.64001	576.70	0.00000E+00	-1362.4	0.00000E+00
3333	-0.05443	-580.00	0.00000E+00	103.98	0.00000E+00
3334	887.10	-1807.3	605.71	-881.40	389.83
3335	158.11	-1480.5	498.08	753.51	-810.08
3336	-8300.1	-1877.5	853.77	45.701	827.03
3337	-8300.0	-1313.3	605.08	1071.6	-320.80
3338	-8081.8	-2850.0	800.15	889.30	316.75

***** POST1 ELEMENT STRESS LISTING *****

LOAD STEP 1 ITERATION= 1 SECTION= 1
TIME= 0.23700 LOAD CASE= 1

ELEM	SDIR	SDZ	SDY1	SDZ2	SDY2
3339	-8004.1	-1750.0	810.00	8161.8	-768.04
3340	-9957.1	-3875.4	1290.0	8307.0	-817.05
3341	-9952.6	840.13	-837.48	7793.0	-581.44
3342	64.600	-420.87	-64.179	181.03	-17.671
3343	-1.5688	813.35	387.55	-1095.3	-773.18
3344	83.098	871.64	824.97	-513.74	-295.06
3345	90.631	810.90	500.05	-1785.7	-1170.0
3346	150.00	1578.4	1301.1	-793.18	-534.41
3347	802.40	1110.1	680.50	-2000.0	-1513.3
3348	800.11	1076.7	1054.0	-1060.5	-907.08
3349	399.73	840.48	801.01	-141.87	-375.14
3350	8781.1	7.0670	485.40	120.30	-8147.3
3351	9005.1	-1896.6	406.80	1076.9	-882.70
3352	1000.4	-1050.2	725.00	1570.0	-1674.1

***** POST1 ELEMENT STRESS LISTING *****

LOAD STEP 1 ITERATION= 1 SECTION= 1
TIME= 0.23700 LOAD CASE= 1

ELEM	SDIR	SDZ	SDY1	SDZ2	SDY2
3353	1214.2	-2844.6	1118.0	1196.6	-425.31
3354	1010.3	-672.15	888.94	1323.4	-940.04
3355	444.83	-1480.8	904.87	843.53	-351.03
3356	301.45	-340.83	187.01	650.41	-480.84
3357	-15.083	-507.60	308.03	877.49	140.06
3358	-309.25	-1683.8	1107.0	-663.84	137.97
3359	-1373.0	-1661.3	614.10	-40.056	106.00
3360	-1780.5	-1958.4	540.00	741.57	-348.38
3361	-8665.0	-8200.0	887.57	84.787	166.38
3362	-8040.1	-1515.8	894.13	1453.4	-490.95
3363	-3770.1	-3807.7	1303.4	810.18	-105.70
3365	-3758.3	-1870.4	687.40	3475.4	-1500.0
3366	-4004.0	-503.81	895.20	7840.8	-1010.3
3367	-803.77	8105.0	56.800	-863.98	47.400

***** POST1 ELEMENT STRESS LISTING *****

LOAD STEP 1 ITERATION= 1 SECTION= 1

571

0.237sec

TIME= 0.23700 LOAD CASE= 1

ELEM	SDIR	SDZ	SDV1	SDZZ	SDV2
[illegible]	-881.37	[illegible].74	84.475	-874.70	-198.89
3368	-778.07	838.44	-847.70	-838.82	818.71
3370	-4773.0	1219.9	-8.9587	-189.90	948.83
3371	-4798.1	888.88	47.717	-884.88	70.680
3372	-8888.3	1433.3	-303.98	-458.17	811.88
3373	-8887.9	888.81	849.89	-1898.8	-18.488
3374	-10000.	388.58	-418.18	-3738.8	1803.8
3375	78.043	-303.88	-17.588	771.48	48.958
3376	488.11	-874.19	-887.08	348.88	887.78
3377	458.74	-385.08	-87.317	857.04	881.94
3378	878.38	-1198.0	-188.57	471.98	184.91
3379	838.09	-488.86	-387.14	897.03	784.11
3380	1118.8	-1148.7	-38.305	843.97	183.84
3381	883.47	0.3888	-48.318	-177.08	-881.10

***** POST1 ELEMENT STRESS LISTING *****

LOAD STEP 1 ITERATION= 1 SECTION= 1
TIME= 0.23700 LOAD CASE= 1

ELEM	SDIR	SDZ	SDV1	SDZZ	SDV2
3382	883.88	1688.7	-134.50	849.98	88.861
3383	31.978	1171.8	84.708	-388.18	-898.07
3384	175.81	881.88	-780.15	-879.65	789.50
3385	-8430.4	1354.8	-11.048	-1173.0	188.81
3386	-8701.4	1376.4	-848.03	-807.42	410.87
3387	-8784.0	410.88	88.308	-1158.1	184.88
3388	-8119.3	885.11	-186.84	-1188.5	190.85
3389	-8113.4	-779.81	-357.38	-8388.1	1784.0
3390	-4.3810	-868.88	-192.89	1994.7	63.110
3391	988.88	-1144.8	-828.17	817.87	713.88
3392	898.07	-478.46	48.498	898.95	170.73
3393	1101.4	-843.08	-848.70	381.80	198.88
3394	1858.4	-888.86	-385.68	887.44	857.08
3395	1888.3	-1050.7	-101.90	580.85	146.88

***** POST1 ELEMENT STRESS LISTING *****

LOAD STEP 1 ITERATION= 1 SECTION= 1
TIME= 0.23700 LOAD CASE= 1

ELEM	SDIR	SDZ	SDV1	SDZZ	SDV2
3396	8888.1	-46.873	-405.79	-38.183	779.88
3397	3112.4	-417.38	1359.7	68.149	-813.48
3402	5304.8	0.67738E+08	0.25567E+08	0.40453E+07	0.18186E+07
3403	5301.5	0.40453E+07	0.18195E+07	-0.17507E+08	-0.66049E+07
3404	5388.8	0.85487E+08	-0.84724E+08	0.89491E+07	-0.33538E+07
3405	5307.0	0.89491E+07	-0.33538E+07	-0.83207E+08	0.87537E+07
3406	5388.9	-0.83207E+08	0.87537E+07	-0.39058E+08	0.15038E+08
3407	5301.5	-0.39058E+08	0.15038E+08	-0.17507E+08	0.66049E+07
3408	5951.9	0.61908E+08	-0.38847E+08	0.88631E+07	-0.46071E+07
3409	5953.4	0.88631E+07	-0.46071E+07	-0.23338E+08	0.12144E+08
3410	5955.0	-0.23338E+08	0.12144E+08	-0.32838E+08	0.17068E+08
3411	5956.1	-0.32838E+08	0.17068E+08	-0.26395E+08	0.13753E+08
3413	5958.6	-0.26395E+08	0.13753E+08	0.14708E+08	-0.76497E+07
3416	5858.6	0.14708E+08	-0.76497E+07	0.55794E+08	-0.29058E+08

***** POST1 ELEMENT STRESS LISTING *****

LOAD STEP 1 ITERATION= 1 SECTION= 1
TIME= 0.23700 LOAD CASE= 1

ELEM	SDIR	SDZ	SDV1	SDZZ	SDV2
3417	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3418	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

POST1 -INP-

0.23 sec

3032	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3033	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3034	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3035	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3036	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3037	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3038	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

***** POST1 ELEMENT STRESS LISTING *****

LOAD STEP 1 ITERATION= 1 SECTION= 1
TIME= 0.23700 LOAD CASE= 1

ELEM	SDIR	SDZ	SDY1	SDZ2	SDY2
3039	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3040	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3041	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3042	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3043	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3044	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3045	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3046	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3047	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3048	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3049	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3050	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3051	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3052	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

***** POST1 ELEMENT STRESS LISTING *****

LOAD STEP 1 ITERATION= 1 SECTION= 1
TIME= 0.23700 LOAD CASE= 1

ELEM	SDIR	SDZ	SDY1	SDZ2	SDY2
3053	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3054	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3055	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3056	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3057	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3058	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3059	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3060	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3061	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3062	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3063	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3064	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3065	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3066	57.889	487.47	929.13	-597.63	-773.88

***** POST1 ELEMENT STRESS LISTING *****

LOAD STEP 1 ITERATION= 1 SECTION= 1
TIME= 0.23700 LOAD CASE= 1

ELEM	SDIR	SDZ	SDY1	SDZ2	SDY2
3070	13.831	-2042.8	-649.06	4091.2	430.49
3071	81.738	650.33	843.33	-795.40	-588.57
3072	12390.	-404.62	-2487.4	1470.1	3490.4
3073	-8457.2	-7534.4	4002.2	8817.1	-5431.9
3074	11.453	701.73	-545.86	-666.47	849.41
3076	-341.86	31.560	2461.4	-717.42	-2776.4
3077	-18350.	-1080.1	-1882.5	2000.5	2833.3
3078	161.53	-116.58	-887.00	47.045	938.36
3079	51.317	2942.0	1384.1	-2566.9	-1264.3
3080	130.29	-687.47	-792.79	557.36	684.12
3081	8.0667	105.33	1573.7	-374.62	-1482.9
3086	5668.6	1306.9	273.63	2.6879	34.064
3087	-1215.0	3493.0	89.907	-3820.7	329.67
3088	-13407.	1642.6	355.04	-813.46	478.81

***** POST1 ELEMENT STRESS LISTING *****

LOAD STEP 1 ITERATION= 1 SECTION= 1
TIME= 0.23700 LOAD CASE= 1

ELEM	SDIR	SDZ	SDY1	SDZ2	SDY2
3089	-1058.0	-837.30	10.421	108.70	-307.17
3090	1618.8	408.28	-159.81	-867.54	548.02
3091	-20.484	-185.40	-13.330	859.93	311.37
3092	-1743.0	130.78	390.07	728.43	603.44
3093	84.308	109.06	-58.051	-166.04	-42.370
3094	1002.5	-500.90	403.76	-360.73	584.07
3095	-19.308	-205.23	44.609	245.83	20.476
3096	-2014.8	435.44	695.68	501.38	532.35
3097	5.1557	90.181	31.672	-130.37	-85.307

3098	1316.8	-381.51	314.83	-878.07	838.33
3099	-318.67	878.67	-803.54	446.38	-309.98
3100	188.06	-107.74	-140.78	-283.68	-842.80
3101	-1876.8	368.90	-805.78	430.98	-209.90
3102	-8086.0	604.77	-717.87	-177.18	368.78

***** POST1 ELEMENT STRESS LISTING *****

LOAD STEP 1 ITERATION= 1 SECTION= 1
TIME= 0.23700 LOAD CASE= 1

ELEM	SDIR	SDZ	SDY1	SDZ2	SDY2
3103	-1.7066	889.88	-888.60	-330.17	-118.31
3104	8885.0	-367.80	48.859	-875.38	531.00
3105	-81.397	-854.18	-87.767	431.84	318.80
3106	-8804.4	887.78	430.06	682.80	628.48
3107	88.900	868.81	-81.680	-818.60	-41.165
3108	8180.8	-448.41	381.95	-448.07	811.50
3109	-186.48	-874.38	4.3408	897.48	38.688
3110	-1842.3	848.09	718.80	390.60	440.54
3111	1887.8	80.931	188.18	-643.70	578.71
3112	-8088.8	818.98	878.03	481.74	438.08
3113	-334.37	-871.09	483.87	378.44	-381.64
3114	133.69	848.04	-383.78	810.74	-871.10
3115	-81.701	445.83	-181.71	807.10	-858.81
3116	-377.08	889.76	-878.10	180.03	-883.11

***** POST1 ELEMENT STRESS LISTING *****

LOAD STEP 1 ITERATION= 1 SECTION= 1
TIME= 0.23700 LOAD CASE= 1

ELEM	SDIR	SDZ	SDY1	SDZ2	SDY2
3117	-309.96	810.78	-811.00	78.608	-806.47
3118	184.18	-818.08	887.44	87.036	-80.043
3119	-8500.8	1383.6	148.58	-887.84	-807.81
3120	-37.834	808.18	8.8864	-473.57	-116.78
3121	8874.1	-188.89	-1718.8	835.89	-1873.4
3122	-118.84	-818.38	-84.360	878.08	830.28
3123	-8834.8	-838.77	-1834.7	18.087	-1385.5
3124	76.486	831.88	-871.55	-840.36	140.68
3125	8480.0	80.478	-1857.0	130.88	-1180.1
3126	-854.98	-840.13	-380.40	874.06	1895.3
3127	-8131.8	-804.43	-1871.8	-10.835	-738.06
3128	96.089	815.36	-880.70	-187.34	183.31
3129	1705.7	80.387	-1370.8	100.96	-784.18
3130	-388.00	-815.17	-403.58	874.50	1411.8

***** POST1 ELEMENT STRESS LISTING *****

LOAD STEP 1 ITERATION= 1 SECTION= 1
TIME= 0.23700 LOAD CASE= 1

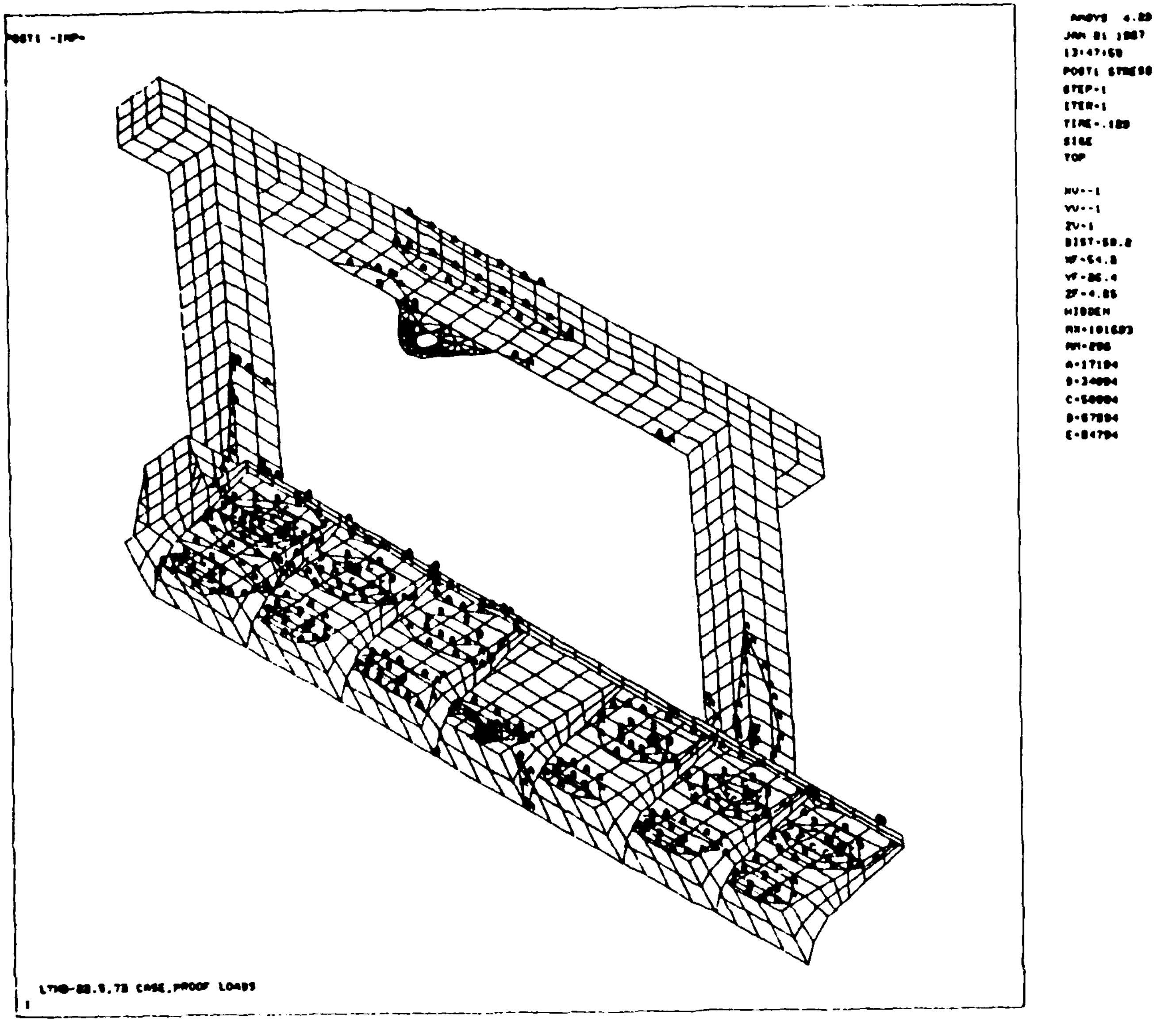
ELEM	SDIR	SDZ	SDY1	SDZ2	SDY2
3131	-1134.1	-188.09	-1044.8	-81.068	-449.67
3132	188.23	180.64	-830.76	-128.07	396.75
3133	-148.36	63.756	-804.10	3.5363	1154.8
3134	899.76	181.18	-485.46	71.187	-1551.0
3135	48.158	38.068	-6.8838	-48.469	83.836
3136	-787.86	-80.778	-1080.3	-83.644	-1687.0
3137	48.148	85.010	-460.57	-75.371	11.678
3140	808.78	74.586	-1882.1	158.30	-1476.5
3141	81.481	-85.730	-808.38	84.788	1834.0
3142	-864.38	-806.54	-1088.8	-28.518	-1011.8
3143	78.388	87.755	-934.84	-78.521	174.18
3144	858.31	45.308	-1782.8	181.41	-887.10
3145	81.590	-83.398	-408.10	118.98	1536.8
3146	-881.31	-166.87	-1898.8	-3.8187	-598.97

***** POST1 ELEMENT STRESS LISTING *****

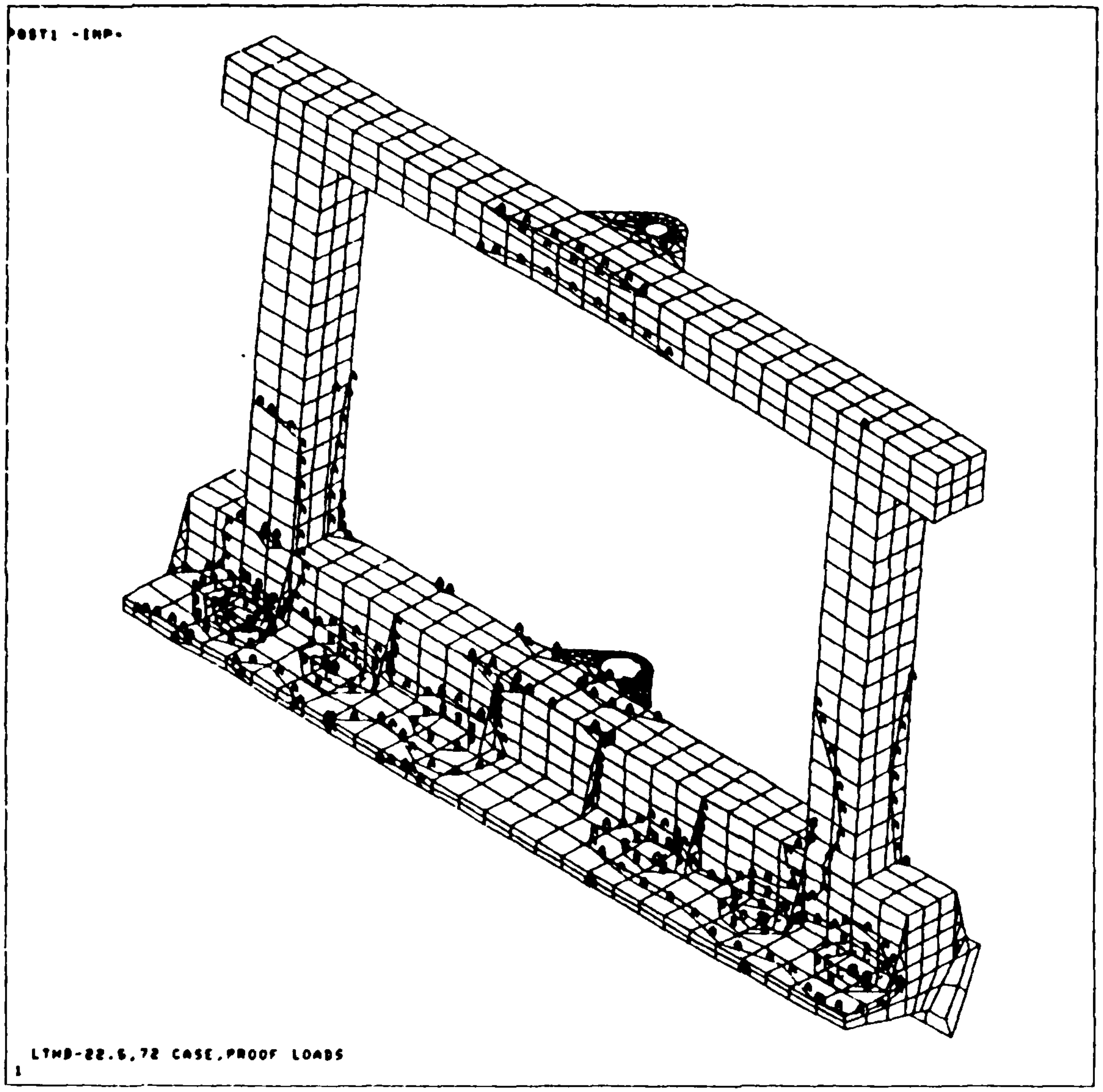
LOAD STEP 1 ITERATION= 1 SECTION= 1
TIME= 0.23700 LOAD CASE= 1

ELEM	SDIR	SDZ	SDY1	SDZ2	SDY2
3147	84.087	186.15	-850.88	-98.006	813.10
3148	881.90	84.075	-1168.8	78.338	18.505
3149	-48.887	-84.083	-840.84	188.44	1374.8
3150	-188.34	-184.16	-780.80	806.15	378.18
3151	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3152	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3153	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3154	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3155	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3156	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
3157	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

t = 0.129 sec



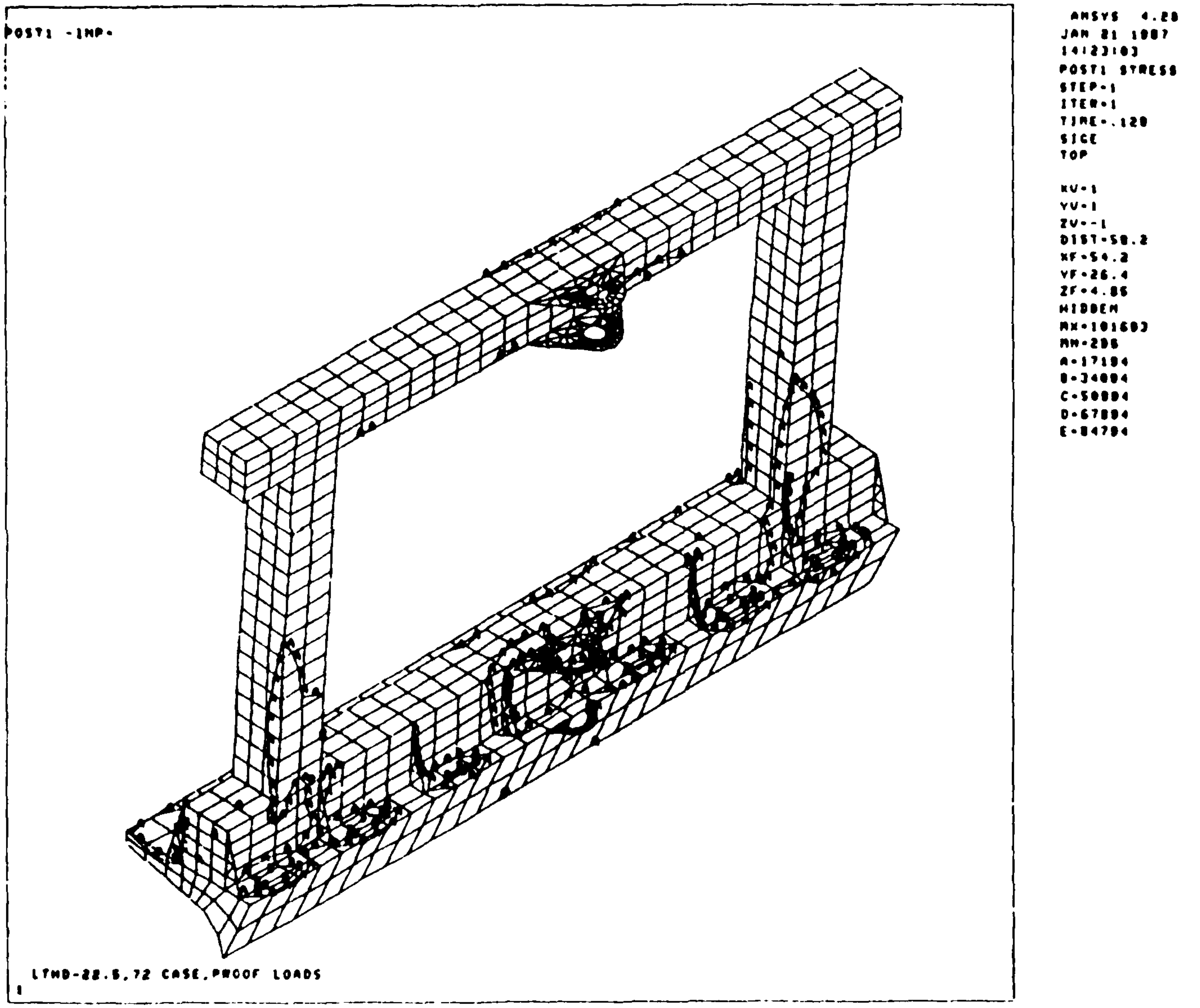
575

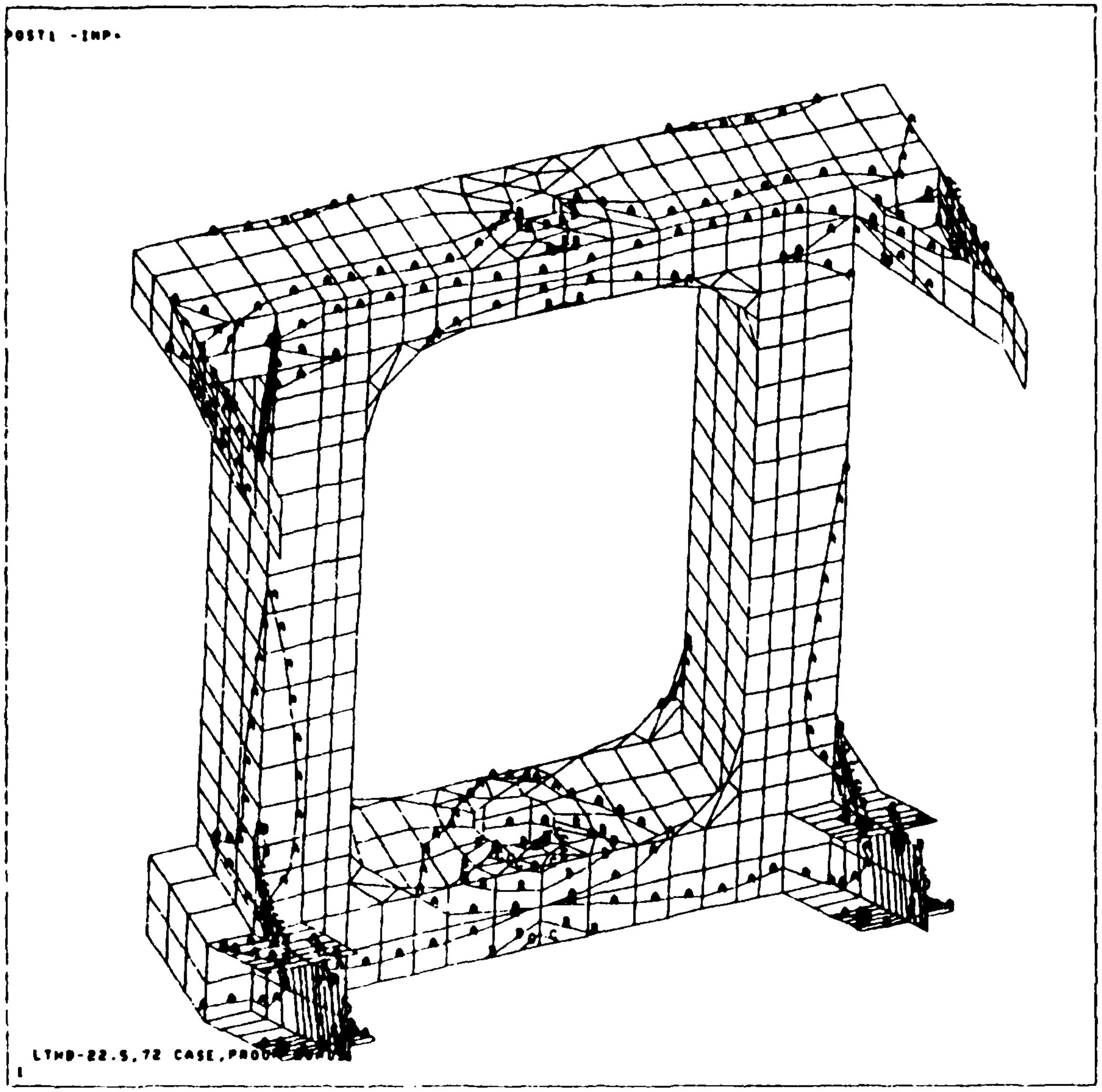


ANSYS 4.2B
JAN 21 1987
14:11:34
POST1 STRESS
STEP=1
ITER=1
TIME=.100
SIGE
TOP

XV=1
YV=1
ZV=1
DIST=56.6
XF=51.2
YF=27.7
ZF=4.17
HIDDEN
MX=101693
MN=296
A=17194
B=34094
C=50994
D=67894
E=84794

576
(...)

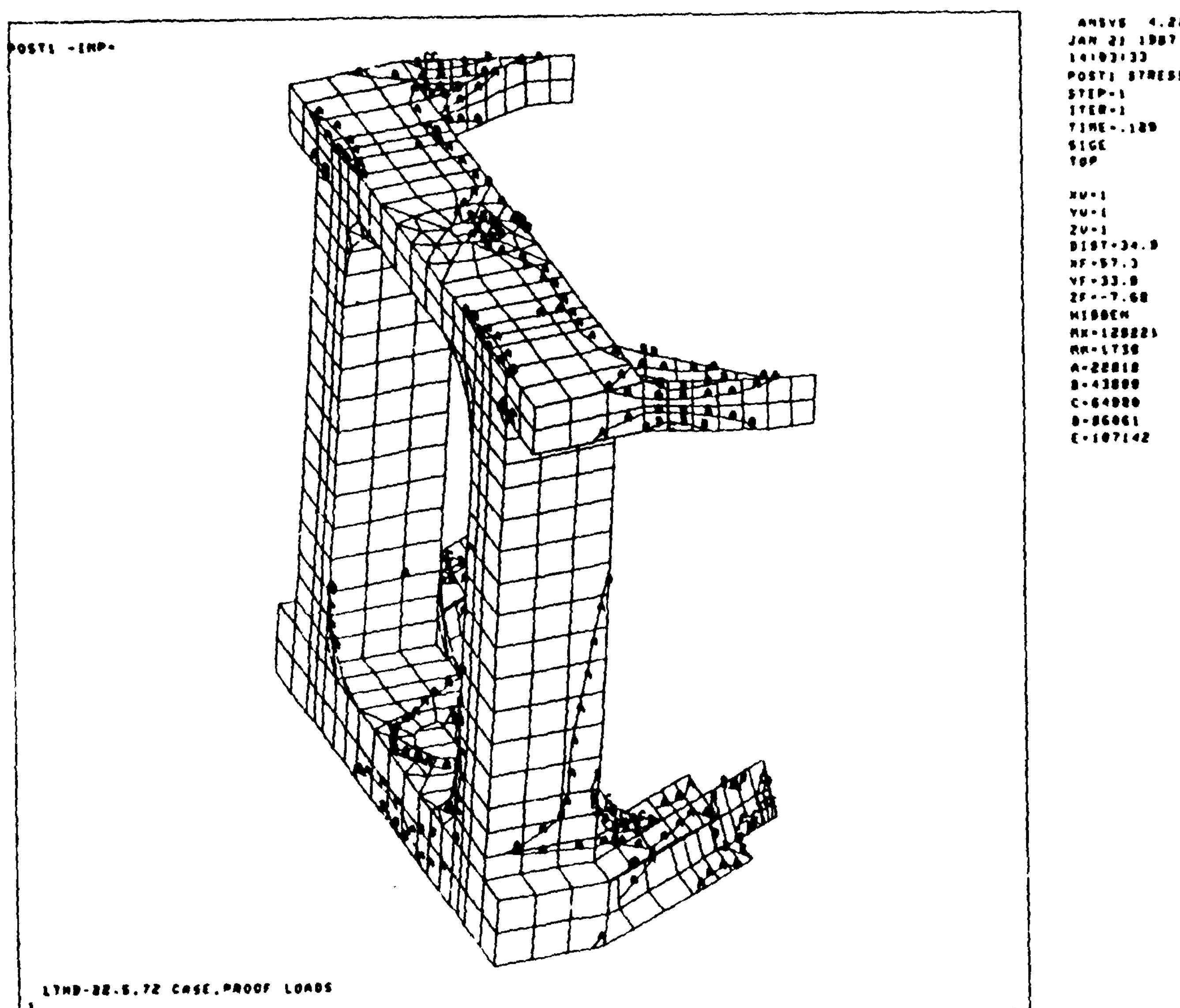

POST1 -INP-
ANSYS 4.2B
JAN 21 1987
14:23:03
POST1 STRESS
STEP=1
ITER=1
TIME=.120
SIGE
TOP
XV=1
YV=1
ZV=-1
DIST=58.2
XF=54.2
YF=26.4
ZF=4.86
HIDDEN
MX=101603
MN=296
A=17194
B=34084
C=50884
D=67894
E=84794
LTHD-22.5,72 CASE,PROOF LOADS



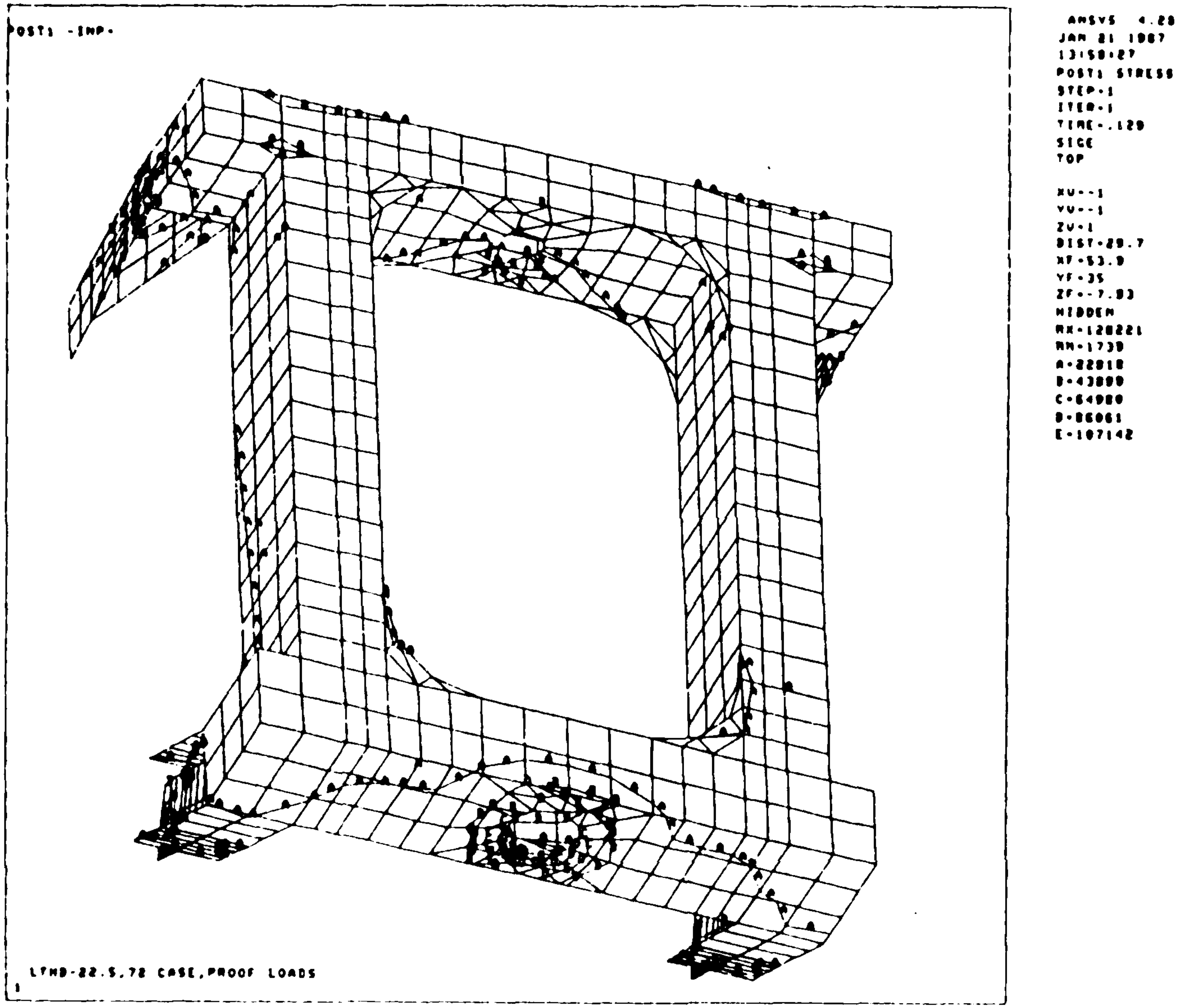
ANSYS 4.2B
JAN 21 1987
14:34:07
POST1 STRESS
STEP=1
ITER=1
TIME=.129
SIGE
TOP

XV=1
YV=1
ZV=-1
DIST=29.7
XF=53.9
YF=35
ZF=-7.03
HIDDEN
MX=128221
MN=1739
A=22818
B=43899
C=64980
D=86061
E=107142

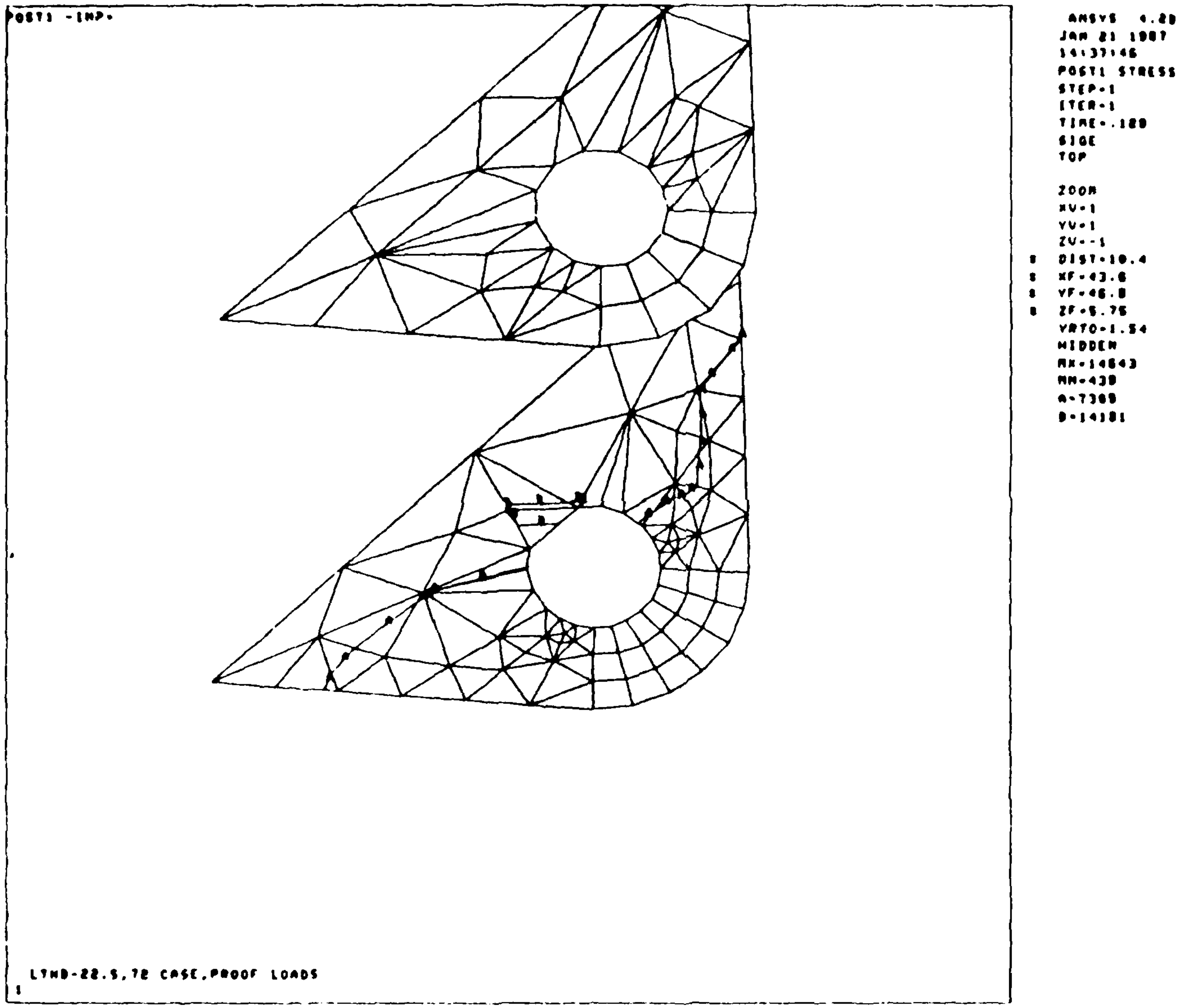
(1)


POST1 -INP-
LTHD-88.5.72 CASE.PROOF LOADS
1
ANSYS 4.2B
JAN 21 1987
14:03:33
POST1 STRESS
STEP=1
ITER=1
TIME=.189
SIGE
TOP
XV=1
YV=1
ZV=1
DIST=34.9
XF=57.3
YF=33.8
ZF=-7.68
HIDDEN
MX=128221
MN=1738
A=22818
B=43899
C=64980
D=86061
E=107142

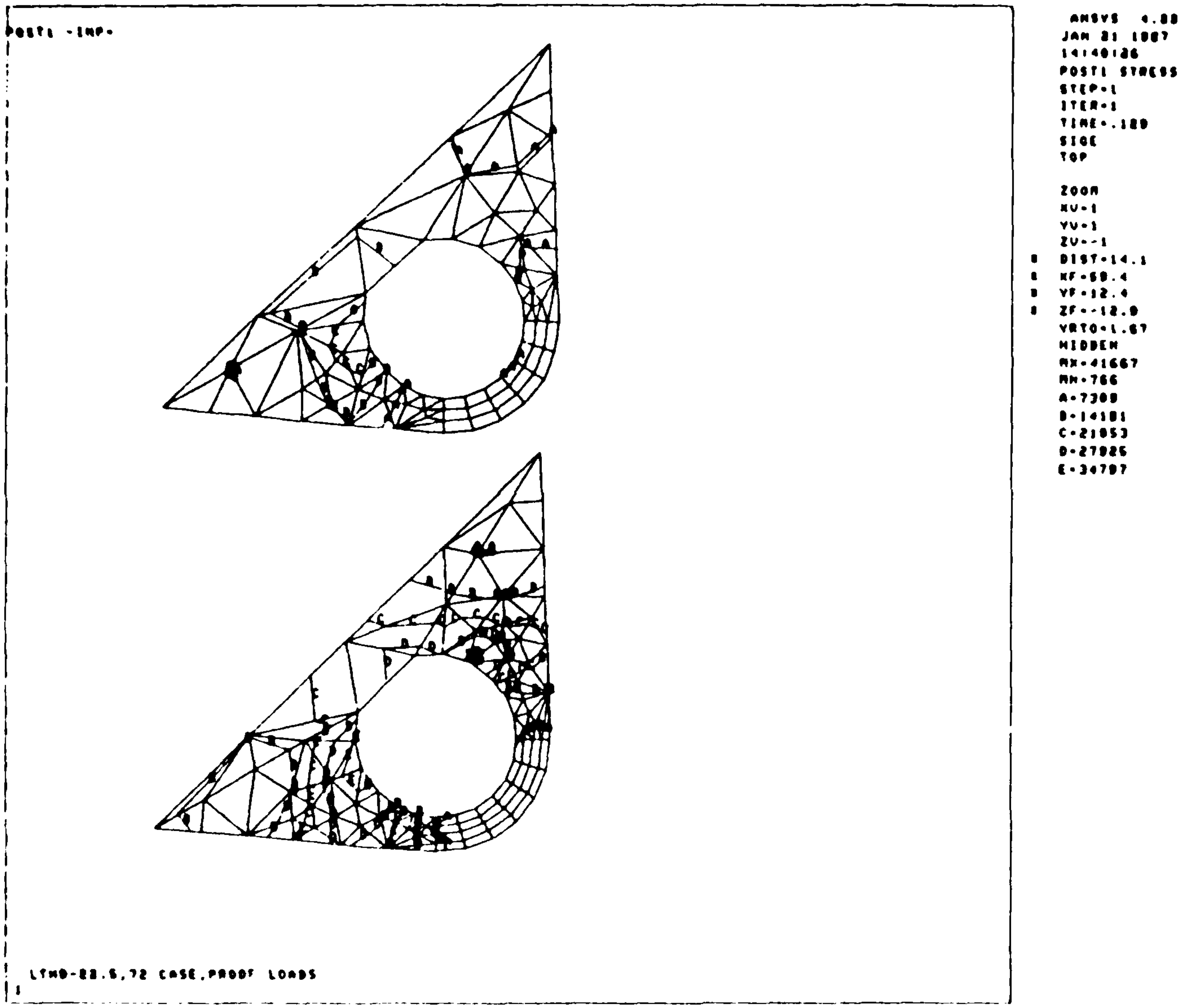
579


POST1 -INP-
LTHD-22.5.72 CASE,PROOF LOADS
ANSYS 4.2B
JAN 21 1987
13:50:27
POST1 STRESS
STEP=1
ITER=1
TIME=.129
SIGE
TOP
XV=-1
YV=-1
ZV=1
DIST=29.7
XF=53.9
YF=35
ZF=-7.93
HIDDEN
MX=128221
MN=1739
A=22818
B=43899
C=64980
D=86061
E=107142

580

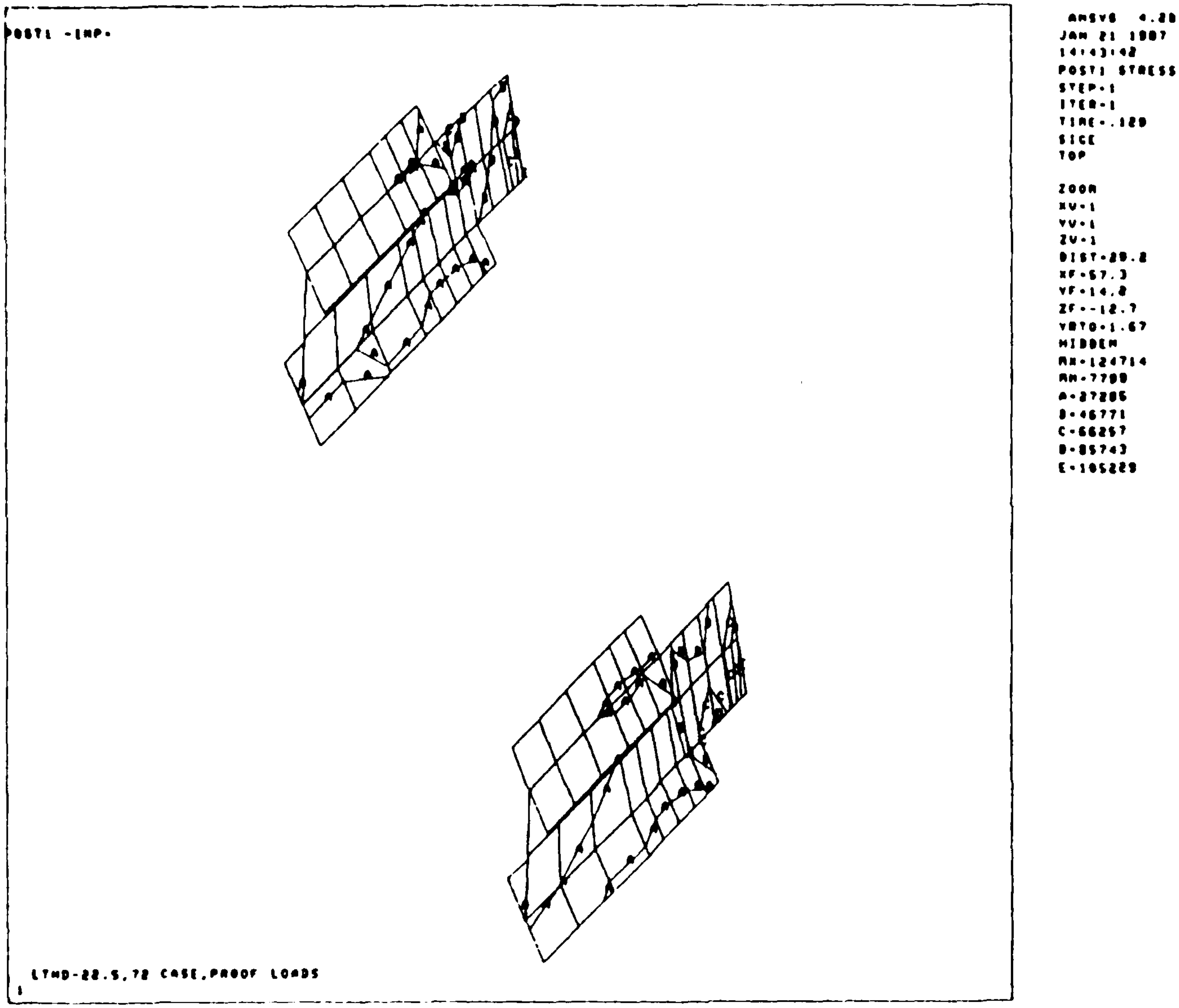

POST1 -INP-
ANSYS 4.2B
JAN 21 1987
14:37:46
POST1 STRESS
STEP=1
ITER=1
TIME=.180
SIGE
TOP
ZOOM
XV=1
YV=1
ZV=-1
DIST=10.4
XF=43.6
YF=46.8
ZF=5.75
VRTO=1.54
HIDDEN
MX=14643
MN=438
A=7389
B=14181
LTHD-22.5,72 CASE,PROOF LOADS

TOP TABS



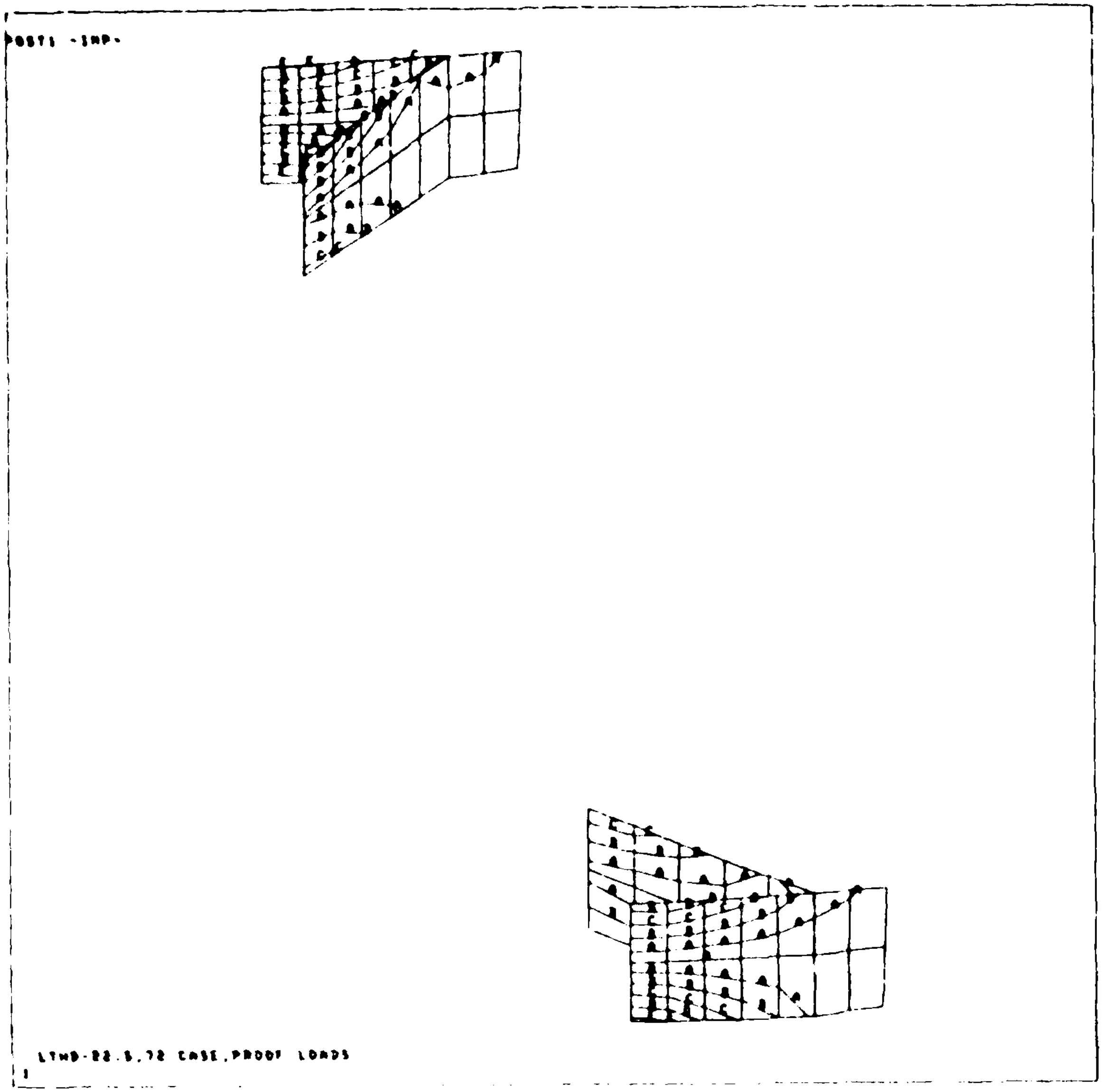
BOTTOM
TABS

582



GIMBAL
LOWER
ARMS

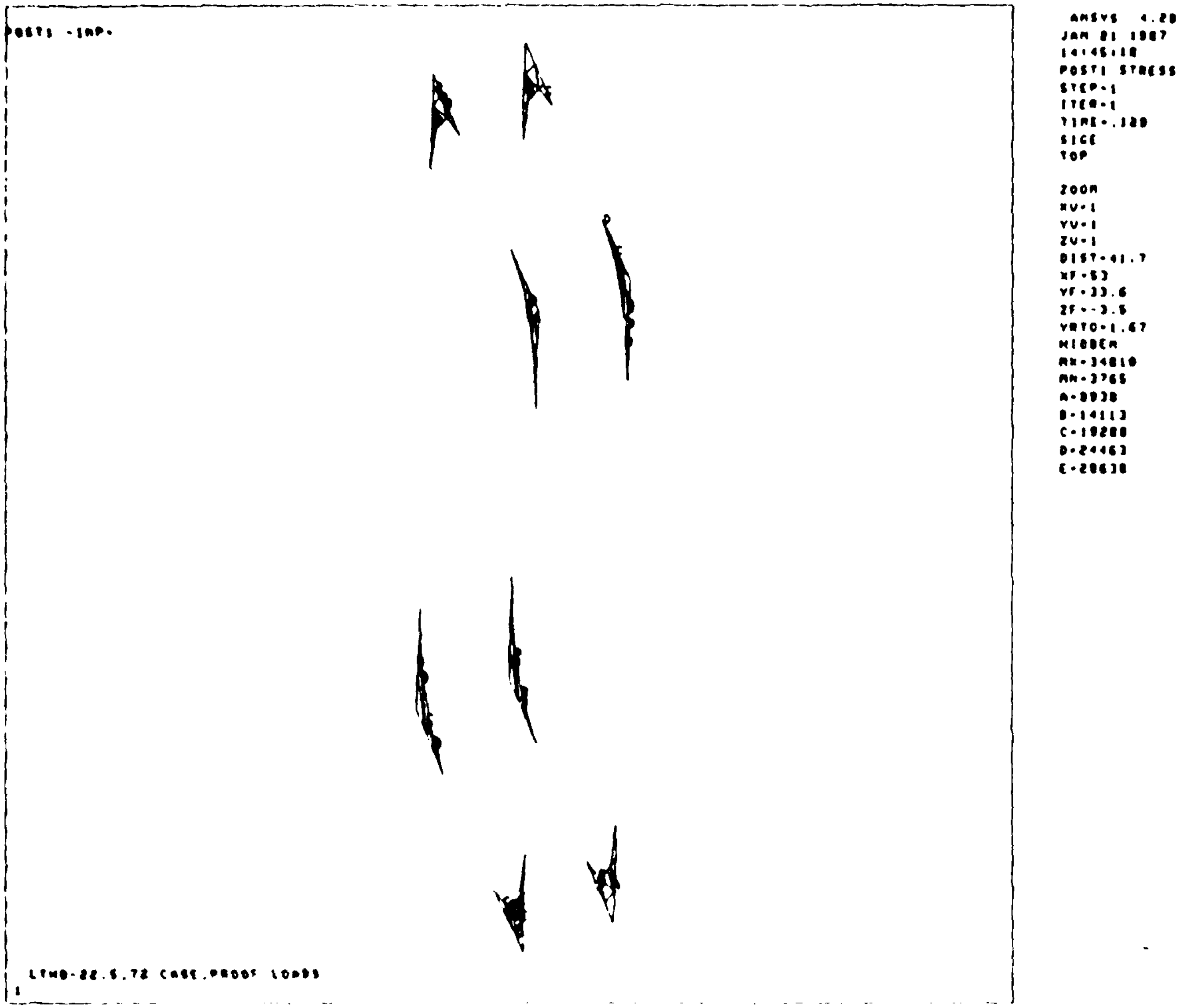
583



ANSYS 4.20
JAN 21 1987
14:44:38
POST1 STRESS
STEP=1
ITER=1
TIME=.180
SIGE
TOP

ZOOM
XV=1
YV=1
ZV=1
DIST=85
XF=57.1
YF=63.3
ZF=-13.8
VRTO=1.67
HIDDEN
MX=77388
MN=6868
A=18621
B=30375
C=42129
D=53883
E=65637

GIMBAL
UPPER
ARMS


POST1 -INP-
LTHD-22.5,72 CASE,PROOF LOADS
1
ANSYS 4.20
JAN 21 1987
14:45:18
POST1 STRESS
STEP=1
ITER=1
TIME=.120
SIGE
TOP
ZOOM
XV=1
YV=1
ZV=1
DIST=41.7
XF=53
YF=33.6
ZF=-3.5
VRTO=1.67
HIDDEN
MX=34810
MN=3765
A=8938
B=14113
C=19288
D=24463
E=29638

0.129 sec

PRINT ELEMENT STRESS ITEMS PER ELEMENT

***** POST1 ELEMENT STRESS LISTING *****

LOAD STEP 1 ITERATION= 1 SECTION= 1
TIME= 0.12900 LOAD CASE= 1

ELEM	SDIR	SBZ	SBY1	SBZ2	SBY2
3069	43.770	-80.486	86.434	106.63	-109.85
3070	-18.696	-4.0083	-418.54	-343.00	502.08
3071	45.706	-71.051	220.78	78.807	-339.34
3072	18398.	-718.31	-1571.4	1715.0	2573.0
3073	-8669.5	1087.8	3584.0	-1153.6	-4463.4
3074	1.4805	-308.62	-546.57	171.91	363.88
3076	-150.85	108.73	1837.6	156.80	-2131.0
3077	-15586.	-931.78	-1534.0	1874.1	8816.4
3078	150.66	-31.197	-943.46	-81.733	899.00
3079	41.563	2544.0	1800.1	-8300.6	-1187.0
3080	117.78	-611.07	-685.46	491.08	608.68
3081	10.404	62.838	1436.7	-886.96	-1311.8
3086	5133.8	426.13	-585.73	537.30	713.67
3087	-238.55	4764.3	1806.9	-4586.6	-543.06

MORE (YES,NO OR CONTINUOUS)=
Y

***** POST1 ELEMENT STRESS LISTING *****

LOAD STEP 1 ITERATION= 1 SECTION= 1
TIME= 0.12900 LOAD CASE= 1

ELEM	SDIR	SBZ	SBY1	SBZ2	SBY2
3088	-9040.8	841.95	-326.39	-46.070	1070.8
3089	-1481.5	-302.03	383.21	433.96	-834.24
3090	401.31	638.80	-291.28	-657.98	880.28
3091	-71.536	-45.790	-191.41	851.96	808.60
3092	-351.65	256.88	348.12	632.74	809.11
3093	3.5504	136.10	-176.09	-63.146	17.428
3094	317.13	-385.86	457.09	-377.00	547.58
3095	-39.370	-54.170	-54.137	127.07	204.26
3096	-294.85	496.17	685.55	510.38	500.16
3097	3.6844	48.166	-30.881	-33.769	18.766
3098	273.26	-282.56	312.25	-489.67	625.03
3099	-282.24	281.85	-264.01	386.90	-388.10
3100	166.05	-78.906	-144.10	-308.94	-544.19
3101	-360.53	350.20	-213.32	418.95	-880.60

MORE (YES,NO OR CONTINUOUS)=

***** POST1 ELEMENT STRESS LISTING *****

LOAD STEP 1 ITERATION= 1 SECTION= 1
TIME= 0.12000 LOAD CASE= 1

ELEM	SDIR	SDZ	SDV1	SDZZ	SDVZ
3100	133.02	104.03	-1110.2	48.433	831.91
3103	30.307	155.18	-373.99	-178.76	130.85
[illegible]	115.02	-300.05	256.02	-380.18	622.30
[illegible]	46.683	-70.300	-154.26	211.05	406.56
[illegible]	00.002	430.10	551.60	578.87	800.87
[illegible]	[illegible]	80.169	-110.74	-4.3274	28.628
[illegible]	70.179	-302.01	525.77	-416.00	556.14
[illegible]	[illegible]	-11.708	-40.999	-22.531	8.1951
[illegible]	02.606	500.84	741.21	200.21	360.33
[illegible]	[illegible]	-112.06	231.13	-302.61	500.13
[illegible]	[illegible]	440.91	296.60	267.16	257.78
[illegible]	903.03	271.93	305.52	363.39	-290.09
[illegible]	[illegible]	315.96	-373.53	348.61	-374.72
[illegible]	[illegible]	200.47	-271.02	326.36	-399.05

***** [illegible] (CONTINUOUS) [illegible]

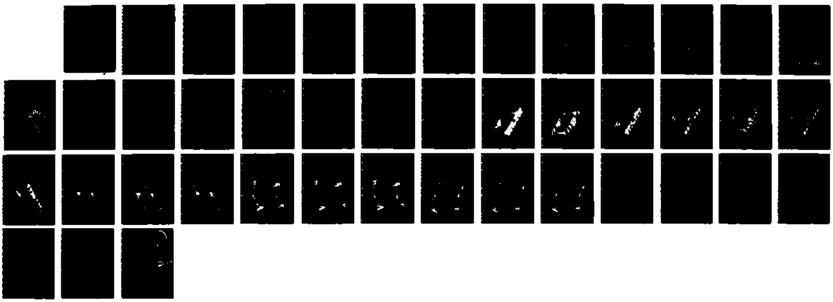
***** POST1 ELEMENT STRESS LISTING *****

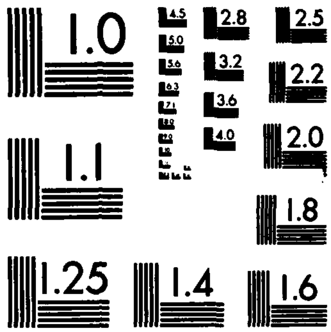
[illegible] ITERATION= 1 SECTION= 1
[illegible] LOAD CASE= 1

ELEM	SDIR	SDZ	SDV1	SDZZ	SDVZ
[illegible]	[illegible]	[illegible]	[illegible]	305.10	-409.17
[illegible]	[illegible]	[illegible]	[illegible]	209.97	-320.50
[illegible]	[illegible]	[illegible]	[illegible]	26.600	-49.710
[illegible]	[illegible]	[illegible]	[illegible]	-601.65	741.21
[illegible]	[illegible]	[illegible]	[illegible]	-162.20	264.22
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	256.03
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	335.54
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	415.94
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	49.808
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	423.04
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	83.856
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	412.11
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-30.938
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	238.25

AD-A183 994 LIGHTWEIGHT TOWED HOWITZER DEMONSTRATOR PHASE 1 AND PARTIAL PHASE 2 VOLUM (U) FMC CORP MINNEAPOLIS MINN NORTHERN ORDNANCE DIV R RATHE ET AL APR 87 2/2

UNCLASSIFIED FMC-E-3041-VOL-D3-PT-2 DAAA21-86-C-0047 F/G 19/6 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

V

***** POST1 ELEMENT STRESS LISTING *****

LOAD STEP 1 ITERATION= 1 SECTION= 1
TIME= 0.12800 LOAD CASE= 1

ELEM	SDIR	SDZ	SDY1	SDZ2	SDY2
3130	26.071	27.263	156.08	-42.532	-306.59
3131	189.92	47.309	420.29	-1.5135	45.600
3132	5.6342	-56.060	361.70	39.793	-103.80
3133	-94.946	1.7191	81.621	-1.8003	-254.20
3134	189.40	57.367	-105.79	-58.157	400.09
3135	35.615	37.967	-243.10	-39.535	402.98
3136	-257.83	34.290	117.42	57.998	322.01
3137	7.7917	28.626	-150.44	-39.991	43.989
3140	305.09	-61.856	176.93	-26.144	364.55
3141	17.346	-25.385	-38.669	83.625	130.90
3142	-344.73	17.651	325.75	74.889	283.92
3143	8.8500	31.873	34.223	-34.065	-5.1531
3144	352.43	-69.642	390.48	-24.281	321.14
3145	-35.099	-37.275	65.718	32.840	-266.21

MORE (YES,NO OR CONTINUOUS)=
Y

***** POST1 ELEMENT STRESS LISTING *****

LOAD STEP 1 ITERATION= 1 SECTION= 1
TIME= 0.12800 LOAD CASE= 1

ELEM	SDIR	SDZ	SDY1	SDZ2	SDY2
3146	-331.89	34.834	425.90	41.926	186.72
3147	5.4790	24.171	258.31	-29.315	-107.33
3148	286.45	-45.247	337.48	14.234	-156.46
3149	-57.060	-20.730	236.59	-1.6803	-490.09
3150	-98.919	22.615	171.32	-62.923	-327.06
3182	-332.37	974.46	-201.56	10145.	4360.2
3183	-945.00	25594.	9427.4	23686.	8998.7
3184	1182.7	35767.	10080.	-7552.6	-3510.1
3185	78.236	140.71	-269.87	0.79314E-03	-38.320
3186	-221.25	625.19	347.65	-0.33644E-02	251.47
3187	-6.1886	46.304	319.36	0.17260E-02	99.516
3188	15.017	-61.257	247.95	0.65919E-03	112.47
3189	-349.19	37.344	-64.766	0.65743E-02	-129.76
3190	-84.639	98.000	76.422	0.46407E-02	-48.956

MORE (YES,NO OR CONTINUOUS)=

588 (9)

```
V

        ***** POST1 ELEMENT STRESS LISTING *****

 LOAD STEP     1  ITERATION=     1  SECTION=  1
 TIME=   0.18900          LOAD CASE=  1

 ELEM      SDIR        SDZ        SDY1          SDZ2        SDY2
 3191    39.808     18.408     -376.18     0.87001E-03 -125.58
 3192   -7.1105     41.617     -20.376    -0.30388E-04 -43.884
 3193   -31.879     3608.9      664.98     0.89647E-01  835.66
 3194    161.86     2313.1     -77.436     0.38018E-01 -107.70
 3195    307.58     1699.5     -956.41     0.48040E-01 -482.73
 3196    814.09     903.11     -3799.8     0.35383E-01 -1888.9
 3197    568.08     1174.0      8659.1     0.43744E-01  1109.7
 3198    345.93     1902.3      685.17     0.37830E-01  358.43
 3199    58.086     2895.5     -158.83     0.33886E-01-0.15800
 3200   -91.648     2224.4     -944.08     0.18068E-01 -381.66
 3201   -141.13     811.24     -893.88     0.18887E-01 -455.18
 3202   -71.358     2048.0     -3456.8     0.13304E-01 -1587.8
 3203   -380.14    -1.7349      8377.5    -0.18118E-01  985.60
 3204   -811.58    -715.34      559.44    -0.46385E-02  317.75
MORE (YES,NO OR CONTINUOUS)=
V

        ***** POST1 ELEMENT STRESS LISTING *****

 LOAD STEP     1  ITERATION=     1  SECTION=  1
 TIME=   0.18900          LOAD CASE=  1

 ELEM      SDIR        SDZ        SDY1          SDZ2        SDY2
 3205   -189.28    -1153.8     -92.814    -0.95478E-03  86.851
 3206   -12.167    -2326.7     -596.61    -0.82389E-02 -814.45
 3207   -101.61     148.08     -85.671     0.80930E-01 -144.77
 3208    458.61    -2456.7      6331.0      1884.6      -2883.6
 3209    1694.6     4042.1     -7992.8    -0.48414E-01 -4968.1
 3210    975.54    -1093.4     -1388.8    -0.56861E-03 -875.41
 3211    813.39    -1836.2      1093.5    -0.59196E-04  357.97
 3212   -180.52    -493.84      1002.8     0.80568E-04  368.84
 3213   -886.05    -1074.4     -364.16    -0.80117E-03 -191.13
 3214    378.81    -2297.5     -548.14    -0.83963E-03 -843.10
 3215    406.74     6495.2     -4341.3     -8481.0       2369.9
 3216    1758.6     815.14     -3271.9    -0.72805E-02 -1582.5
 3217    649.89    -857.78      7928.8    -0.88791E-01  3946.6
 3218    782.79    -3166.4     -50.336    -0.55110E-02  115.56
MORE (YES,NO OR CONTINUOUS)=
```

***** POST1 ELEMENT STRESS LISTING *****

LOAD STEP 1 ITERATION= 1 SECTION= 1
TIME= 0.12000 LOAD CASE= 1

ELEM	SDIR	SDZ	SDY1	SDZ2	SDY2
3819	-7.1000	-1060.0	-747.47	-0.13034E-02	-389.75
3820	-8365.9	3813.3	1383.7	84434.	11518.
3821	-4018.1	89183.	13387.	80308.	13281.
3822	-3738.0	38135.	10040.	-10975.	588.04
3823	-8138.6	188.04	308.77	0.37076E-03	105.84
3824	-8400.8	152.00	188.10	0.63811E-04	58.893
3825	-1893.8	113.58	-0.62746	0.11580E-04	11.141
3826	-358.60	85.017	-12.483	0.16546E-05	-0.73775
3827	98.016	13.182	0.65605E-01	0.14817E-05	-0.19110
3828	130.74	7.6673	-8.7459	-0.45498E-06	-0.18796
3829	-874.40	47.018	84.188	0.50897E-06	1.7868
3830	-8503.9	78.403	-10.709	0.41889E-05	-14.944
3831	-8481.9	79.585	-145.49	0.15319E-04	-43.035
3832	-3515.3	5.0571	-250.38	0.20984E-04	-93.331

MORE (YES,NO OR CONTINUOUS)=
Y

***** POST1 ELEMENT STRESS LISTING *****

LOAD STEP 1 ITERATION= 1 SECTION= 1
TIME= 0.12000 LOAD CASE= 1

ELEM	SDIR	SDZ	SDY1	SDZ2	SDY2
3833	1011.5	88.086	33.981	0.33441E-03	18.897
3834	1287.9	-6.7807	55.934	0.15665E-04	17.064
3835	1286.0	101.34	-20.763	0.28734E-03	-8.8034
3836	3098.3	88.450	-10.761	0.25613E-03	-7.6327
3838	4705.7	37.776	-31.424	0.20937E-03	-14.155
3839	4841.3	-39.518	-101.99	0.15828E-03	-34.948
3840	3143.6	-0.47581	-178.26	-0.41967E-04	-58.360
3841	2029.6	96.640	11.450	0.34878E-03	7.0496
3842	-352.60	25.017	-12.483	0.16546E-05	-0.73775
3843	3715.1	80.020	19.136	0.29430E-03	10.796
3844	4860.7	22.997	58.382	0.24105E-03	28.352
3845	-1404.0	-109.05	23.393	-0.81851E-03	8.2891
3846	-2312.3	-148.83	8.3158	-0.94837E-03	5.7546
3847	-4203.6	-127.36	19.829	-0.90916E-03	11.158

MORE (YES,NO OR CONTINUOUS)=

***** POST1 ELEMENT STRESS LISTING *****

LOAD STEP 1 ITERATION= 1 SECTION= 1
TIME= 0.10000 LOAD CASE= 1

ELEM	SDIR	SBZ	SBYT	SBZB	SBYB
3848	-1837.6	-98.970	-886.83	-0.353330E-03	-64.589
3849	-4868.9	-104.08	-115.41	-0.141306E-08	-30.180
3850	-3314.6	-101.13	-18.911	-0.833650E-03	-8.8886
3851	-8645.8	104.88	36.389	0.830815E-03	11.887
3852	18.149	-8.8481	-86.184	-0.803056E-04	3.4766
3853	-1180.5	15.889	-5.8755	0.755475E-05	-0.98378
3854	3846.8	-97.381	-0.91766	-0.803645E-04	0.15188
3855	-987.43	-9.4854	139.58	-0.881485E-04	43.589
3856	-1810.5	-18.738	143.98	-0.104185E-08	58.818
3857	718.61	-86.814	-36.089	-0.888865E-03	-15.619
3858	-5114.1	-38.345	84.589	-0.779085E-03	85.888
3859	-3314.6	-101.13	-18.911	-0.833658E-03	-8.8886
3860	-384.55	-358.16	-16.969	-0.167885E-08	-7.9148
3861	1875.1	-79.867	1.1897	-0.865805E-03	0.80407

MORE (YES,NO OR CONTINUOUS)=
Y

***** POST1 ELEMENT STRESS LISTING *****

LOAD STEP 1 ITERATION= 1 SECTION= 1
TIME= 0.10000 LOAD CASE= 1

ELEM	SDIR	SBZ	SBYT	SBZB	SBYB
3862	6814.1	-11.158	18.857	1.5891	-8.1368
3306	-1.4466	977.00	0.00000E+00	1348.8	0.00000E+00
3310	-1.5858	-638.89	0.00000E+00	-3147.8	0.00000E+00
3317	0.870000E-01	708.83	0.00000E+00	-678.38	0.00000E+00
3318	0.905670E-01	604.80	0.00000E+00	-758.83	0.00000E+00
3320	-0.89670	-128.10	0.00000E+00	185.88	0.00000E+00
3321	-1.8736	803.33	0.00000E+00	-1305.8	0.00000E+00
3322	0.15853	-138.80	0.00000E+00	128.79	0.00000E+00
3323	0.90035	1062.6	0.00000E+00	-8166.7	0.00000E+00
3324	0.80537	-2217.1	0.00000E+00	1588.3	0.00000E+00
3325	0.88803	-1927.1	0.00000E+00	1846.8	0.00000E+00
3326	-0.330360E-01	-113.57	0.00000E+00	109.90	0.00000E+00
3327	0.93800	18158.	0.00000E+00	-774.08	0.00000E+00
3328	0.93800	-774.08	0.00000E+00	-13706.	0.00000E+00

MORE (YES,NO OR CONTINUOUS)=

***** POST1 ELEMENT STRESS LISTING *****

LOAD STEP 1 ITERATION= 1 SECTION= 1
TIME= 0.12000 LOAD CASE= 1

ELEM	SDIR	SBZ	SBY1	SDZ2	SBY2
3329	0.16367E-10	-0.53580E-06	0.00000E+00	0.12060E-08	0.00000E+00
3330	-1.0000	-77.080	0.00000E+00	68.300	0.00000E+00
3331	0.34123	-140.14	0.00000E+00	130.93	0.00000E+00
3332	-0.20031	987.84	0.00000E+00	-2038.0	0.00000E+00
3333	-0.57678	-1375.8	0.00000E+00	885.18	0.00000E+00
3334	76.330	-108.83	104.91	400.48	-853.14
3335	65.014	587.36	-250.98	-158.30	40.558
3336	98.904	783.10	-380.13	-80.383	18.401
3337	98.886	401.18	-167.48	-592.66	230.65
3338	-45.430	590.74	-259.45	-259.46	151.80
3339	-50.963	27.408	-4.8306	-486.33	808.07
3340	-381.73	147.90	101.40	-306.93	-250.15
3341	-290.84	-286.36	-505.84	289.86	1793.8
3342	0.3007	163.04	80.430	-98.718	-59.374

MORE (YES,NO OR CONTINUOUS)=
Y

***** POST1 ELEMENT STRESS LISTING *****

LOAD STEP 1 ITERATION= 1 SECTION= 1
TIME= 0.12000 LOAD CASE= 1

ELEM	SDIR	SBZ	SBY1	SDZ2	SBY2
3343	170.16	-95.774	-144.68	288.88	807.64
3344	380.87	-295.47	-853.17	126.56	188.66
3345	405.36	-192.10	-224.72	340.86	439.76
3346	611.96	-427.39	-374.30	133.90	183.38
3347	705.10	-104.62	-184.18	198.39	355.48
3348	859.84	-329.97	-317.23	50.898	809.16
3349	898.73	-51.216	-72.704	95.857	10.100
3350	-214.18	921.12	1034.8	-1377.0	-899.83
3351	-852.44	47.050	-546.00	6.3012	855.80
3352	-234.44	109.13	-56.719	-357.00	304.80
3353	-800.33	336.84	-315.91	-172.77	170.99
3354	-150.62	807.41	-150.27	-458.00	375.02
3355	-97.561	467.40	-369.60	-265.67	808.39
3356	-110.76	62.592	-32.923	-98.878	79.807

MORE (YES,NO OR CONTINUOUS)=

592

▼

***** POST1 ELEMENT STRESS LISTING *****

LOAD STEP 1 ITERATION= 1 SECTION= 1
TIME= 0.18000 LOAD CASE= 1

ELEM	SDIR	SBZ	SBY1	SBZ2	SBY2
3357	8.8543	111.85	-46.824	-87.308	-86.168
3358	83.694	-809.09	86.391	572.03	-842.70
3359	-646.37	536.10	-884.08	146.38	-11.307
3360	-850.31	401.24	-195.89	-469.50	150.56
3361	-1350.0	687.46	-375.05	-160.69	172.71
3362	-1353.8	859.80	-85.685	-546.10	870.11
3363	-8108.9	403.37	-820.90	-817.08	801.50
3365	-8111.1	77.050	13.610	-306.80	813.33
3366	-8653.7	510.81	-60.396	-469.38	1740.9
3367	-859.06	1909.9	61.868	-855.58	7.0435
3368	-577.10	914.04	86.549	-851.06	-14.807
3369	-586.55	501.85	-54.834	-585.90	61.177
3370	-1407.1	1874.9	-88.103	-133.19	83.790
3371	-1400.1	717.85	47.681	-810.74	-10.815

MORE (YES,NO OR CONTINUOUS)=
▼

***** POST1 ELEMENT STRESS LISTING *****

LOAD STEP 1 ITERATION= 1 SECTION= 1
TIME= 0.18000 LOAD CASE= 1

ELEM	SDIR	SBZ	SBY1	SBZ2	SBY2
3372	-1951.4	1535.6	-59.690	-385.70	100.80
3373	-1953.9	609.44	41.884	-1685.8	44.537
3374	-8566.3	539.68	-188.86	-4419.0	850.64
3375	39.654	-344.88	-68.095	688.40	147.59
3376	89.058	-705.75	-197.86	399.44	188.54
3377	97.708	-308.30	-83.102	665.57	144.09
3378	161.76	-1062.4	-142.09	465.66	84.507
3379	150.45	-448.59	-183.42	1040.0	319.80
3380	857.35	-1140.3	-804.58	613.50	837.58
3381	334.66	30.839	176.33	-185.85	-886.19
3382	613.44	1412.8	-82.535	868.85	-85.193
3383	469.38	715.15	-88.194	-85.356	5.6098
3384	494.64	618.73	9.9583	-507.75	-19.144
3385	458.78	1488.4	-7.7828	-936.10	-4.0656

MORE (YES,NO OR CONTINUOUS)=

593

(3)

***** POST1 ELEMENT STRESS LISTING *****

LOAD STEP 1 ITERATION= 1 SECTION= 1
TIME= 0.12000 LOAD CASE= 1

ELEM	SDIR	SBZ	SBY1	SBZ2	SBY2
3386	873.80	1500.5	10.530	-388.05	-84.358
3387	867.97	697.14	-7.6691	-1808.7	8.8400
3388	161.64	1171.5	138.61	-1850.6	-854.40
3389	186.31	-800.36	-387.90	-3183.5	1148.7
3390	1.7774	-145.00	-185.34	740.47	133.77
3391	-0.90185	-901.83	-153.63	511.28	78.180
3392	84.448	-345.87	-78.963	598.40	90.114
3393	1.0081	-573.56	-100.67	318.65	67.577
3394	38.448	-598.30	-111.07	1164.8	197.78
3395	75.880	-1140.0	-888.55	591.18	130.84
3396	80.374	-838.28	-120.53	453.00	844.11
3397	384.59	-635.84	854.46	318.13	-843.93
3402	3776.7	0.67777E+08	0.25570E+08	0.40888E+07	0.18179E+07
3403	3774.0	0.40888E+07	0.18179E+07	-0.17518E+08	-0.66050E+07

MORE (YES,NO OR CONTINUOUS)=
Y

***** POST1 ELEMENT STRESS LISTING *****

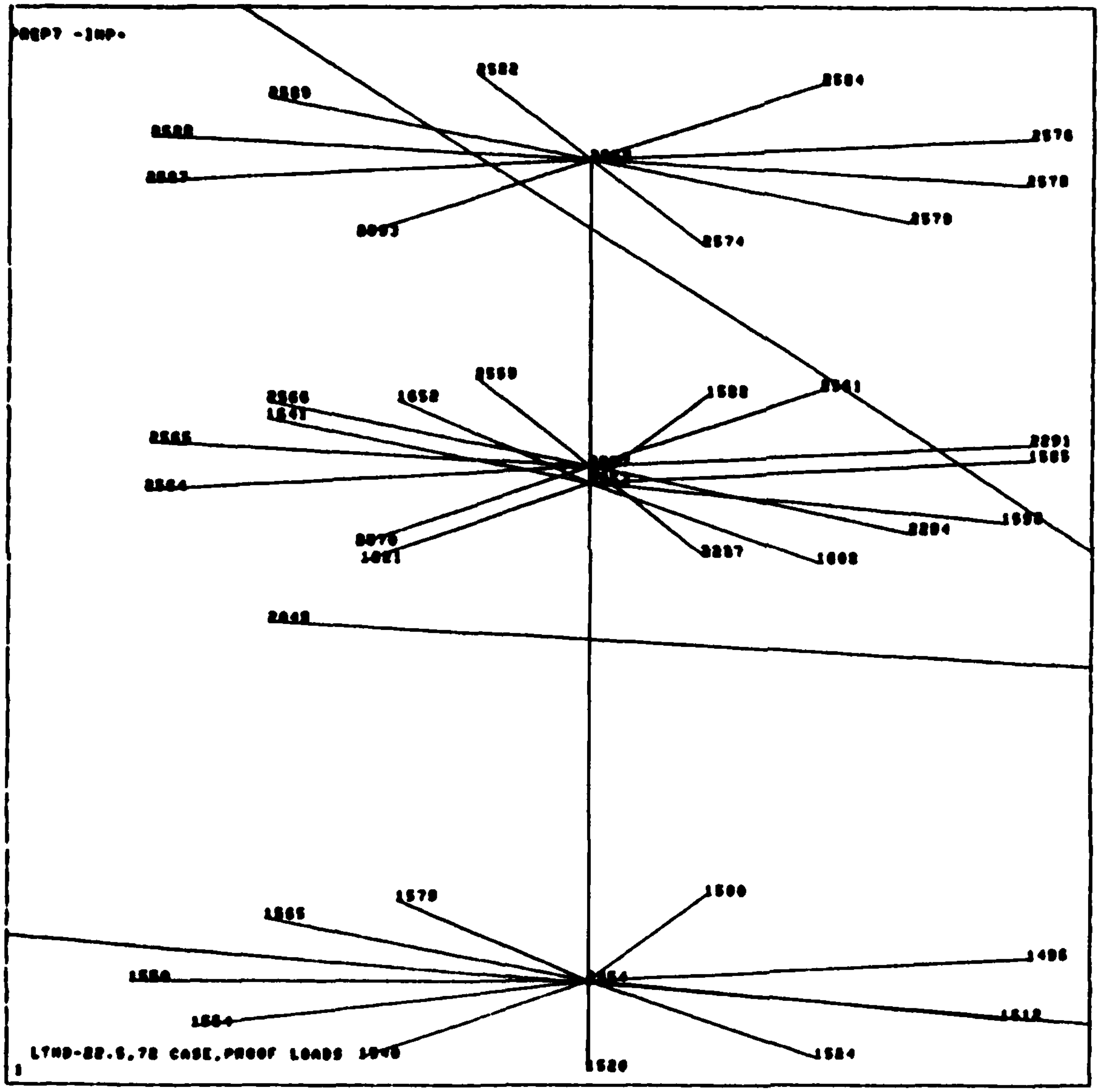
LOAD STEP 1 ITERATION= 1 SECTION= 1
TIME= 0.12000 LOAD CASE= 1

ELEM	SDIR	SBZ	SBY1	SBZ2	SBY2
3404	3768.7	0.65509E+08	-0.24728E+08	0.89450E+07	-0.33550E+07
3405	3770.3	0.89450E+07	-0.33550E+07	-0.23813E+08	0.87548E+07
3406	3771.4	-0.23813E+08	0.87548E+07	-0.39847E+08	0.15029E+08
3407	3774.0	-0.39847E+08	0.15029E+08	-0.17518E+08	0.66050E+07
3408	4073.0	0.61814E+08	-0.32246E+08	0.88595E+07	-0.46077E+07
3409	4074.4	0.88595E+07	-0.46077E+07	-0.23344E+08	0.12146E+08
3410	4076.0	-0.23344E+08	0.12146E+08	-0.32820E+08	0.17081E+08
3411	4077.2	-0.32820E+08	0.17081E+08	-0.26417E+08	0.13755E+08
3412	4079.6	-0.26417E+08	0.13755E+08	0.14699E+08	-0.76496E+07
3416	4079.6	0.14699E+08	-0.76496E+07	0.55814E+08	-0.29064E+08

POST1 -INP=

594

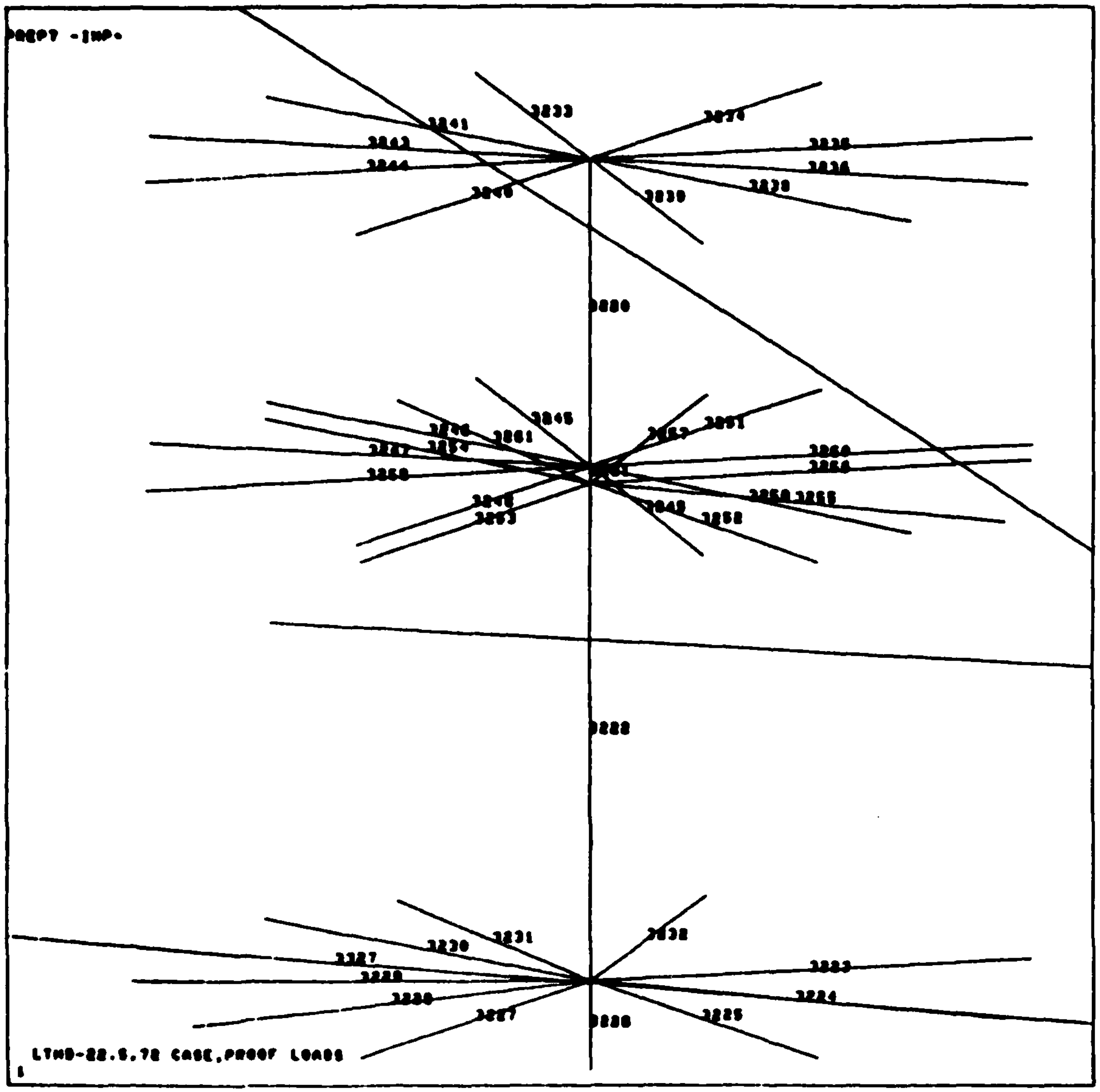
(99)



ANSYS 4.2B
JAN 23 1987
11:14:01
PREP7 ELEMENTS
NNUM=1

ZOOM
XV=-1
YV=-1
ZV=1
* DIST=38.6
* XF=148
* YF=96.6
* ZF=-92.6
XRTO=12.2
YRTO=4.18

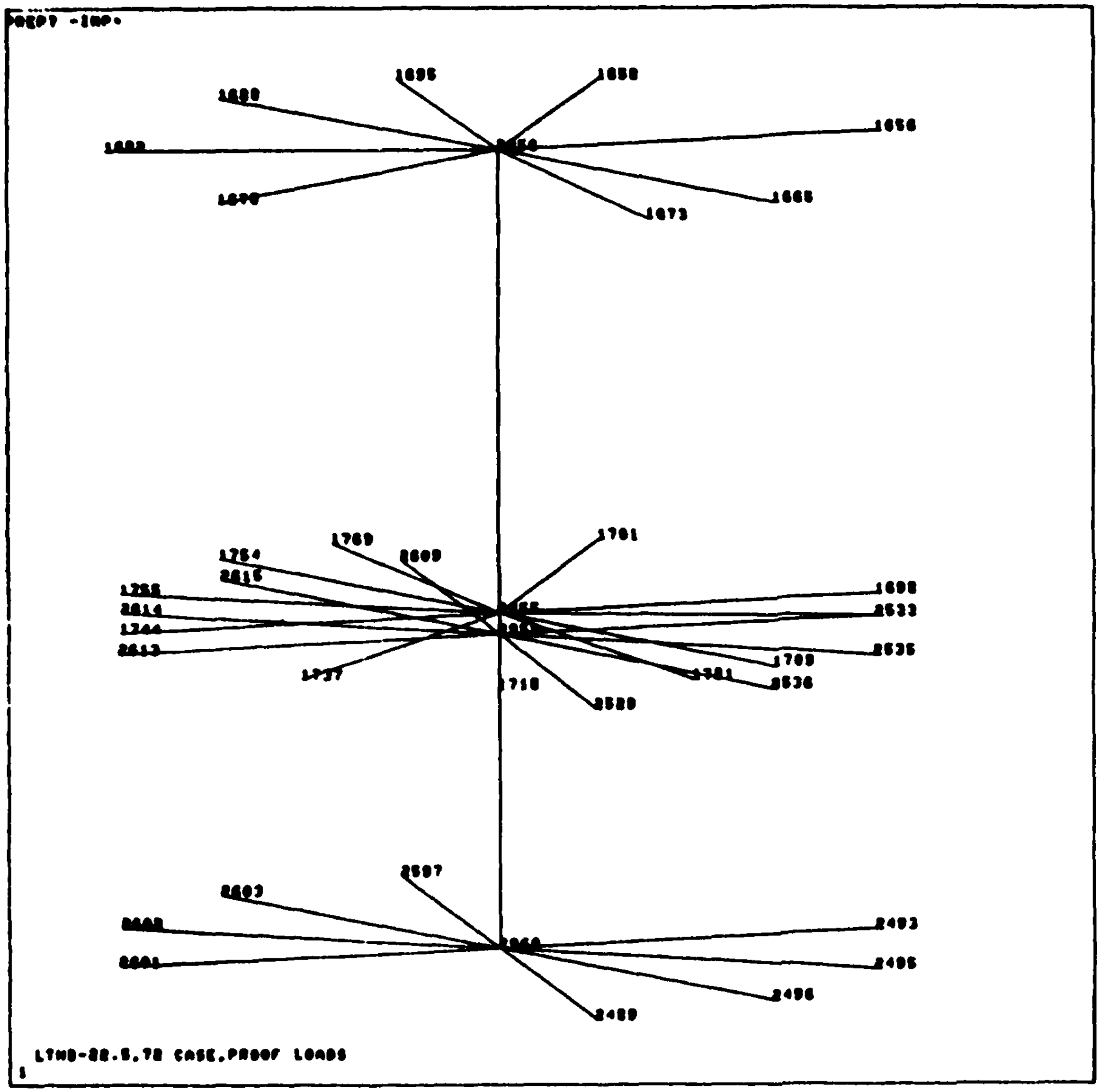
LOWER
SHAFT
NODES



ANSYS 4.2B
JAN 23 1987
11:13:41
PREP7 ELEMENTS
ENUM=1

ZOOM
XV=-1
YV=-1
ZV=1
* DIST=32.6
* XF=142
* YF=96.6
* ZF=-92.6
XRTO=18.8
YRTO=4.18

LOWER
SHAFT
ELEMENTS

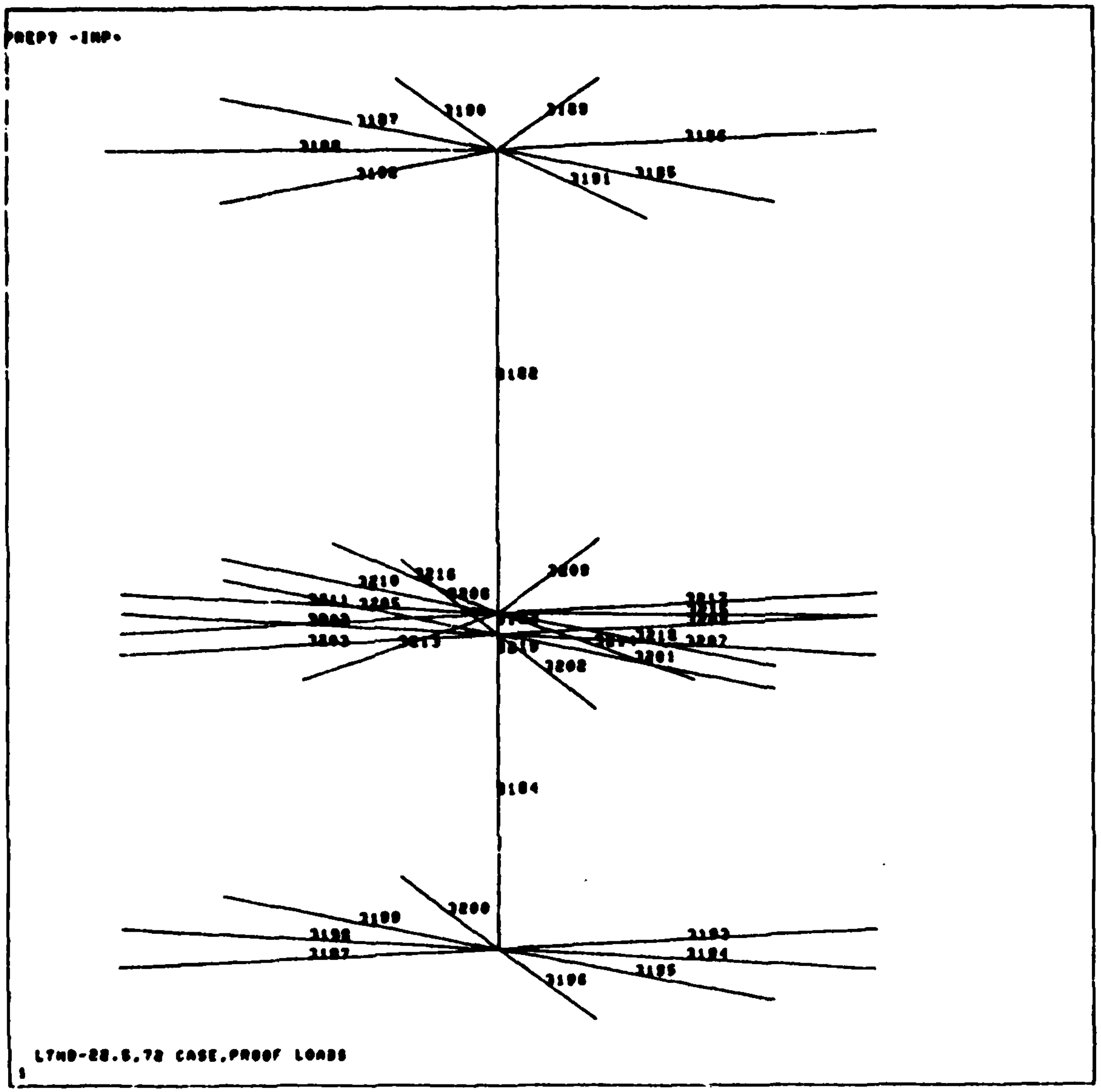


ANSYS 4.2B
JAN 23 1987
11:14:25
PREP7 ELEMENTS
NNUM=1

ZOOM
XV=-1
YV=-1
ZV=1
DIST=37
XF=125
YF=130
ZF=-75.6
XRTO=10.4
YRTO=6.51

UPPER SHAFT
NODES

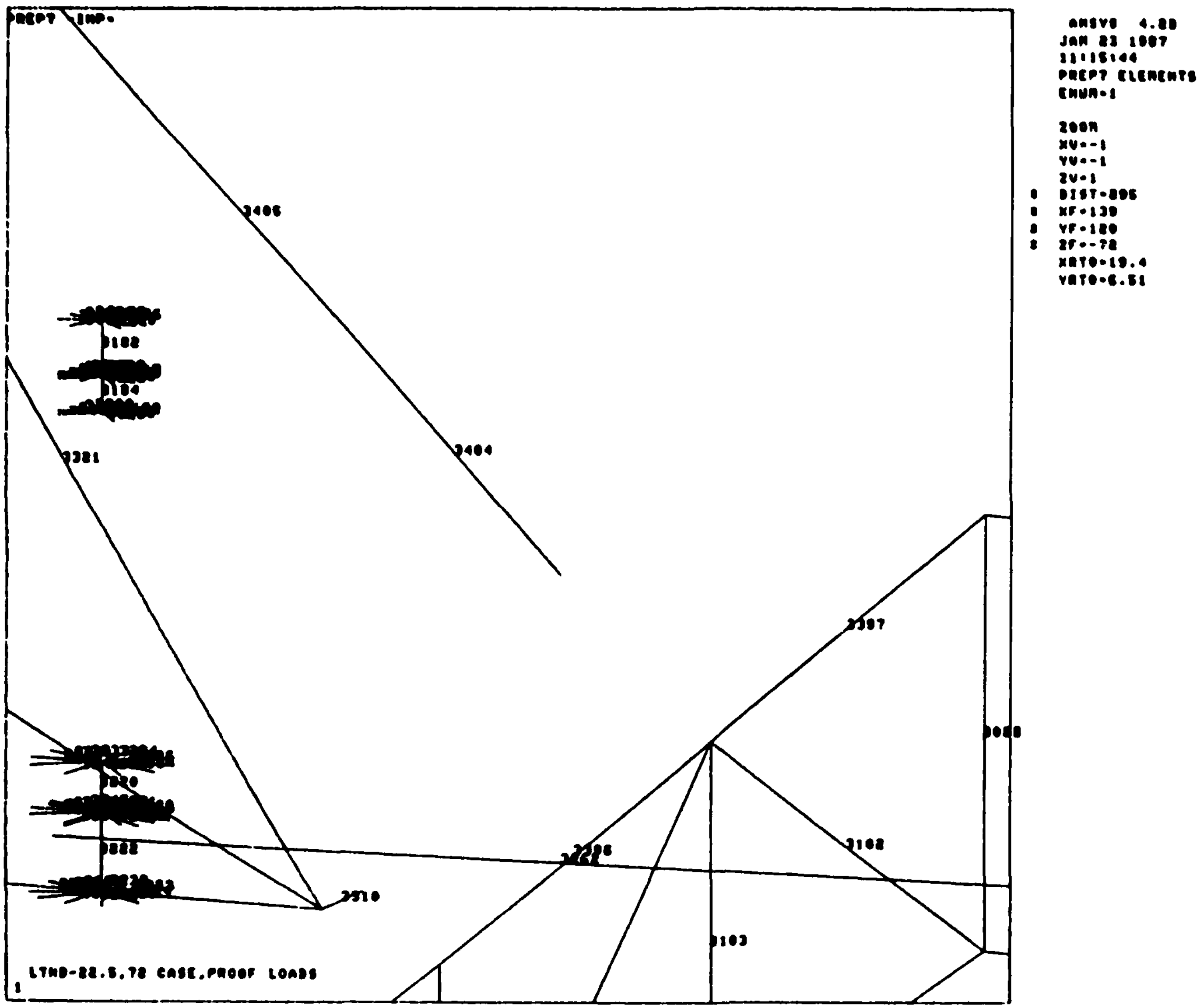
498



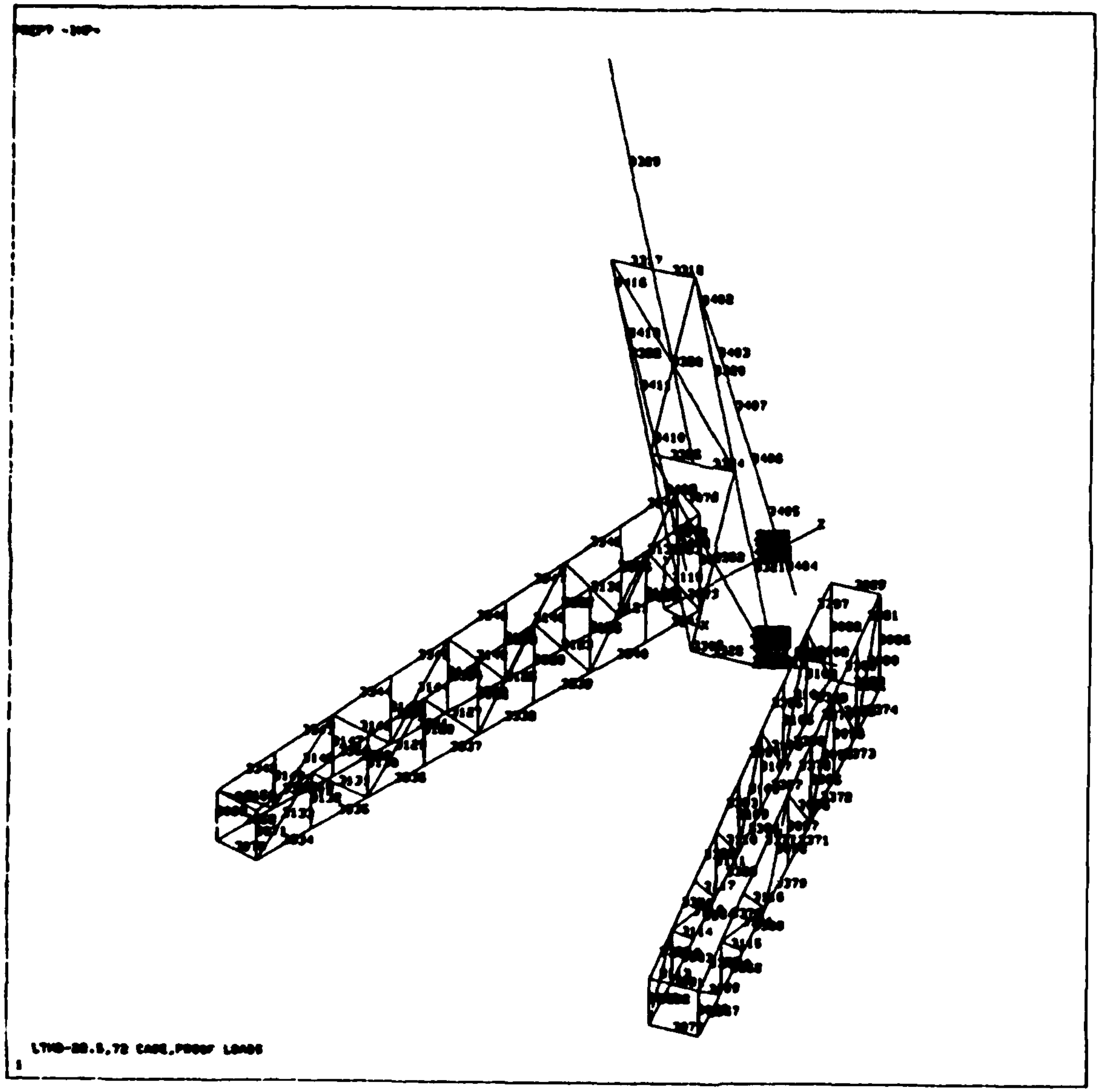
ANSYS 4.2B
JAN 23 1987
11:15:27
PREP7 ELEMENTS
ENUM=1

ZOOM
XV=-1
YV=-1
ZV=1
* DIST=37
* XF=185
* YF=130
* ZF=-75.8
XRTO=18.4
YRTO=6.51

UPPER SHAFT
ELEMENTS


ANSYS 4.2B
JAN 23 1987
11:15:44
PREP7 ELEMENTS
ENUM=1
ZOOM
XV=-1
YV=-1
ZV=1
DIST=895
XF=139
YF=180
ZF=-72
XRTO=19.4
YRTO=6.51
PREP7 INP=
3406
3404
3381
3397
3108
3103
3310
LTHD-22.5.7B CASE,PROOF LOADS

600



LTHD-80.5,72 CASE,PROOF LOADS

ANSYS 4.2B
JAN 23 1987
11:18:04
PREP7 ELEMENTS
ENUM=1

XV=-1
YV=-1
ZV=1
DIST=811
XF=89.4
YF=138
ZF=-180
XRTO=4.06
YRTO=3.64

D3/210

CEL MEMO: JANUARY 28, 1987

FMC Central Engineering Laboratories
Santa Clara

Interoffice

To J. Ries

Date Jan. 28, 1987

From C. R. Ortloff

cc E. Thuse
A. Amberg
R. Kazares
R. Rathe
L. Libhardt

Subject **REMAINING TASKS ON THE LWHD PROJECT - COST/BENEFIT ANALYSIS FOR SEVERAL PROPOSED TASK**

To date (1-28-87) about $43K out of $65K authorized has been expended for labor charges on system analysis tasks. Allowing for a $15K expenditure by M. Rodamaker for cradle analysis tasks, and a $5K recapture from C. C. Chen, about $12K remains, without consideration of computer charges. Retroactive computer charges starting 1-1-87 essentially reduce the remaining budget to a few thousand dollars. Further clarification is needed on the start date for these charges as well as an understanding on final management agreements on general issues regarding computer charges past 1-28-87. *

From a phone conversation with you (JR) on 1-28-87, the request was made to list important analysis tasks remaining together with cost estimates (including labor and computer charges). Accordingly, these tasks are listed below:

1. Computation of the effects of a "soft soil" model on system stress levels and stability. Linear springs will be input between the spade and ground to model the rearward motion of the system as the spade compresses the "soft soil" under recoil and torque impulse loads applied to the cradle.

   The 0^o-0^o or 22.5^o-0^o FE system model will be used as the rearward reaction force is largest for these cases. Stress contour plots for the gimbal and platform for "soft soil" and "hard soil" spade emplacement will be made and compared to assess the magnitude of the difference. Results will determine the amplification/dimunition effect of the soil model on stress levels. Results will be reported in memo form.

   Nc gen. charge.

   one-run - no instability

Labor: (Set-up, Report & Postprocessing time)	25 hours	= $2,000
Computer charges: 30 CPU hours @ $125/hour		= $3,750
Total:		$5,750

2. Modification of the existing FE system model to incorporate the next design iteration in the platform and gimbal structure (plus a possible update in trail and cradle "beam" representations). The magnitude of this task depends on the degree of FEM modification required. An estimate of (say) one week (labor) for model modification and a computer run for the "worst load case" is as follows:

   need firm out

Labor:(Model Modification, Report & Postprocessing)54 hrs. = $4,400
Computer Charges: 50 CPU hours @ $125/hour = $6,250
(includes average of interactive and batch run times)
Total: $10,400

probably more than this

Totals for this task may be higher if FE model changes are very significant (or lover if only local thickness changes are prescribed).

3. Computation of static 16g LAPES loads on a system model with folded trails.

Labor: (Model Modification, Postprocessing & Final Memo) 30 hours = $2,400
Computer Charges: 30 CPU hours @ $125/hour = $3,750
Total: $6,150

old geometry

No

For the above, a run involving towing loads could be substituted for the same cost.

4. Final report (includes results of Item 2)

Labor: 60 hours = $5,000

yes

5. Detailed multilamina FE model of the nev cradle design and layer-by-layer analysis of stresses, deflections and failure mechanisms. This run vill be a static analysis and dynamic amplification factors from M. Rodamaker's analysis vill be used to obtain maximums of the dynamic stress state. Use of part of these computed results can be used in an inertial buckling analysis to determine cradle stability under impulse loads. The nev FE model vill be for the current cradle geometry, cable mount and (nev) materials selection.

old geom

No.

Labor: (includes nev FE model, postprocessing time and final memo) 60 hours = $ 4,800
Computer charges: 60 CPU/hours @ $125/hour = $ 7,500
Total $12,300

The above tasks 1, 2 and 4 total $11,400 for labor and $12,000 for computer charges and probably constitute the minimum vork package necessary to assure that the nev system design is adequate. Tasks 3 and 5 are optional but serve to increase confidence in the adequacy of the design.

CROrtloff

C. R. Ortloff

CRO/870128/01

Recommend do 2, and 4.
My estimate
≈ $17K
Have 2 done about mid-Feb

As an addendum to this memo, a few additional comments on Task 5 are in order. As in prior cradle analyses, a detailed FE model needs to be made for this task. Use of ANSYS STIF 53 (3 node composite elements) and STIF 45 (8 node isoparametric elements) will reduce run times considerably. Use of the maximum stress failure criteria will be continued for the following reason: Since the Tsai-Hill failure ellipse lies within the maximum stress rectangle in stress space, if the structure fails based on maximum stress criteria, it will certainly fail based on Tsai-Hill criteria. Thus, use of the maximum stress criteria gives some margin of conservatism in the design.

One remaining concern with the cradle is local buckling (or crippling) of the edge-loaded Gr/Ep sandwich structure near the forward manifold under proof impulse loads. Some computer work can be done in this task to investigate this effect. Certainly, this problem should be addressed in the test phase of future work on the cradle. Since ARDEC appears interested in tests/calculations that are at hot, wet composite conditions, the analysis tasks can easily include these effects and uncover problems that may be missed in the test phase unless environmental test chambers are used. Additional tasks related to thermal expansion deformation and stress levels can also be addressed by this task item.

CRDitoff

D3/220

CEL MEMO: FEBRUARY 12, 1987

FMC Central Engineering Laboratories
Santa Clara

Interoffice

To: L. Libhardt*

Date: Feb. 12, 1987

From: C. R. Ortloff

cc: E. Thuse, A. Amberg, R. Kazares, D. Langerud, R. Rathe, J. Ries

Subject: **STATIC PROOF LOAD ANALYSIS OF THE LWHD SYSTEM MODEL (22.5°-72° LOAD CASE)**

Attached are Figures 602-623* detailing the equivalent stress and UX, UY, UZ deflections of the gimbal and platform under statically applied proof loads. The recoil and firing torque maximum load vectors are decomposed into X, Y and Z components and applied at their normal point(s) of application on the beam representation of the cradle. In this manner, the subsidiary effects of the cradle "moment arm" are preserved with respect to load transmittal into the gimbal/platform and spade. For the present run, the trail ends are subject to a UY=0 constraint based on the fact that these ends rest on the ground while static loads are applied. An additional 1g gravity load is applied uniformly to all discrete and continuously distributed masses in the model. The spade is fixed at its lower edge while the horizontal spade plate is subject to UY=0 constraints.

Stresses shown are for the TOP (outside), MIDDLE and BOTTOM (inside) surface planes of STIF 43 plate elements used to compose the FE model. The SIGE stress follows the definition

$$\sigma_E = \frac{1}{\sqrt{2}}\sqrt{(\sigma_{xx}-\sigma_{zz})^2+(\sigma_{xx}-\sigma_{yy})^2+(\sigma_{yy}-\sigma_{zz})^2+6(\tau_{xy}^2+\tau_{xz}^2+\tau_{yz}^2)}$$

where σ_{ii} denotes normal stress and τ_{ij} denotes shear stress. The plasticity criteria used is σ_E = 120 ksi; this value denotes the boundary between elastic and plastic regions (for which $\sigma_E > 120$ ksi). The coordinate system used is shown in Figure 609. All displacements are with respect to global axes. Note that some of the UZ displacements toward the top part of the platform are large. As the lower arms of the gimbal absorb all of the proof recoil loads, a large moment (M_x) is input into the platform causing bending in the -Z direction. Note also that deflections are calculated on the basis of linear elasticity even though stresses may exceed the yield stress value. Actual deflections, calculated on the basis of plasticity theory, would be larger than elastic values shown (although stresses would be less than those shown).

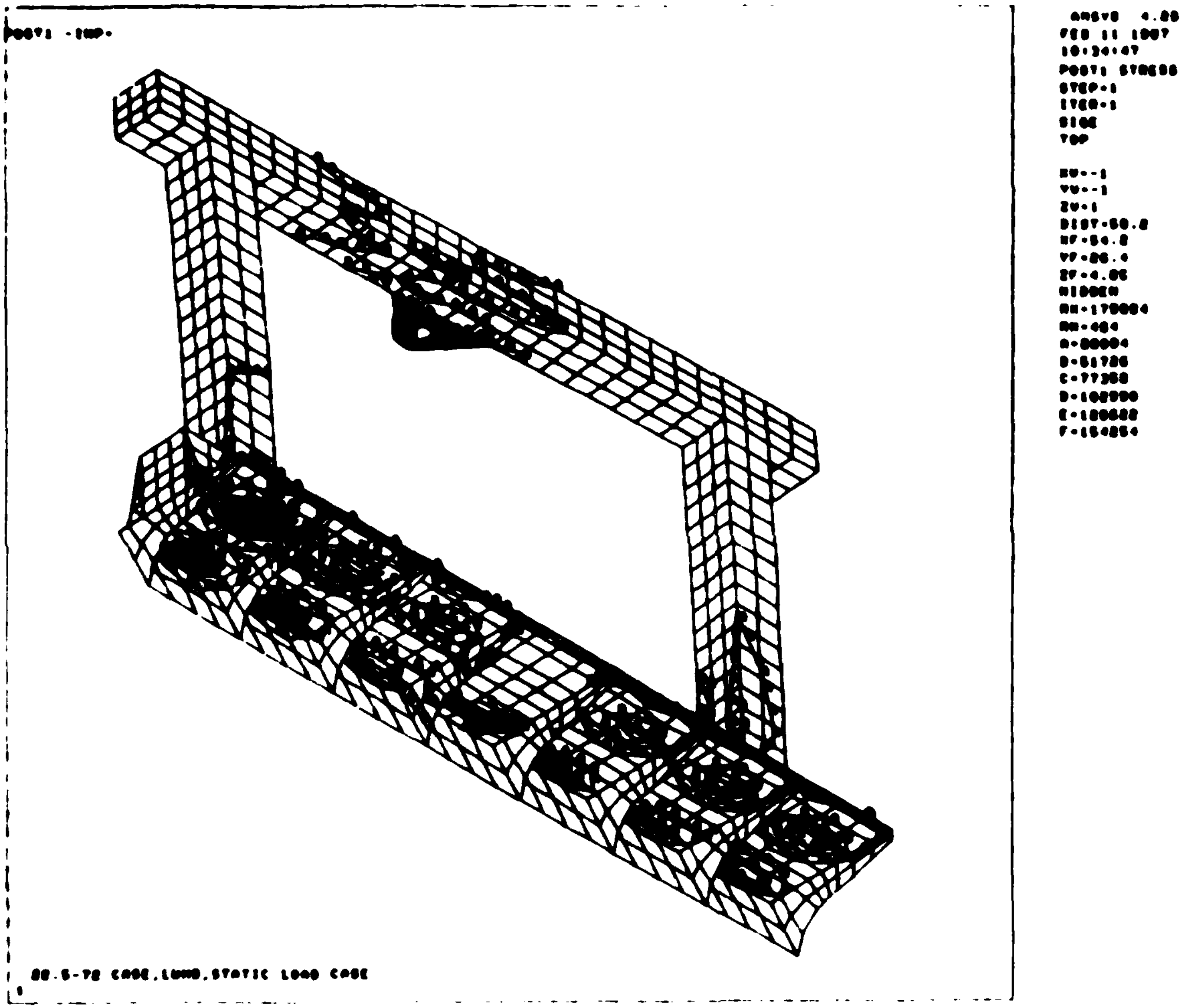
Comparison of results from this load case to that run on the basis of dynamic input load (Memo: CRO to R. Rathe, 1-26-87) gives some indication as to dynamic amplification factor for stress and deflection levels.

CRO 870212 01

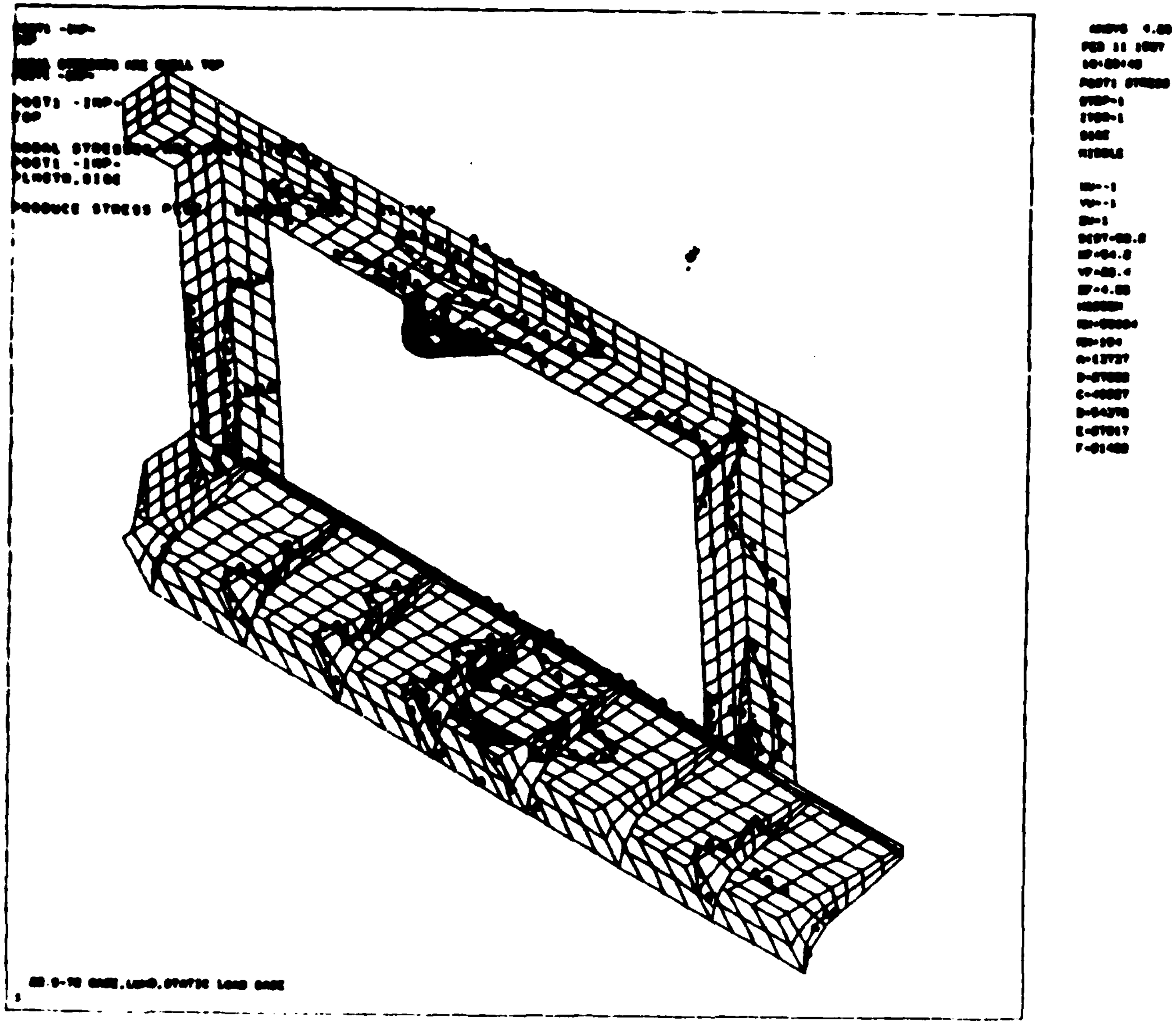
As a further note on thermal expansion effects in the Gr/Ep cradle, it should be noted that the "through the thickness" thermal expansion coefficient can be 20-50X the in-plane thermal expansion coefficient. It may be important to include these effects and examine stress and deflection results in the vicinity of ply-drop-off regions and fillet regions where the Gr/Ep layers transition into "thick walls."

CROrtloff

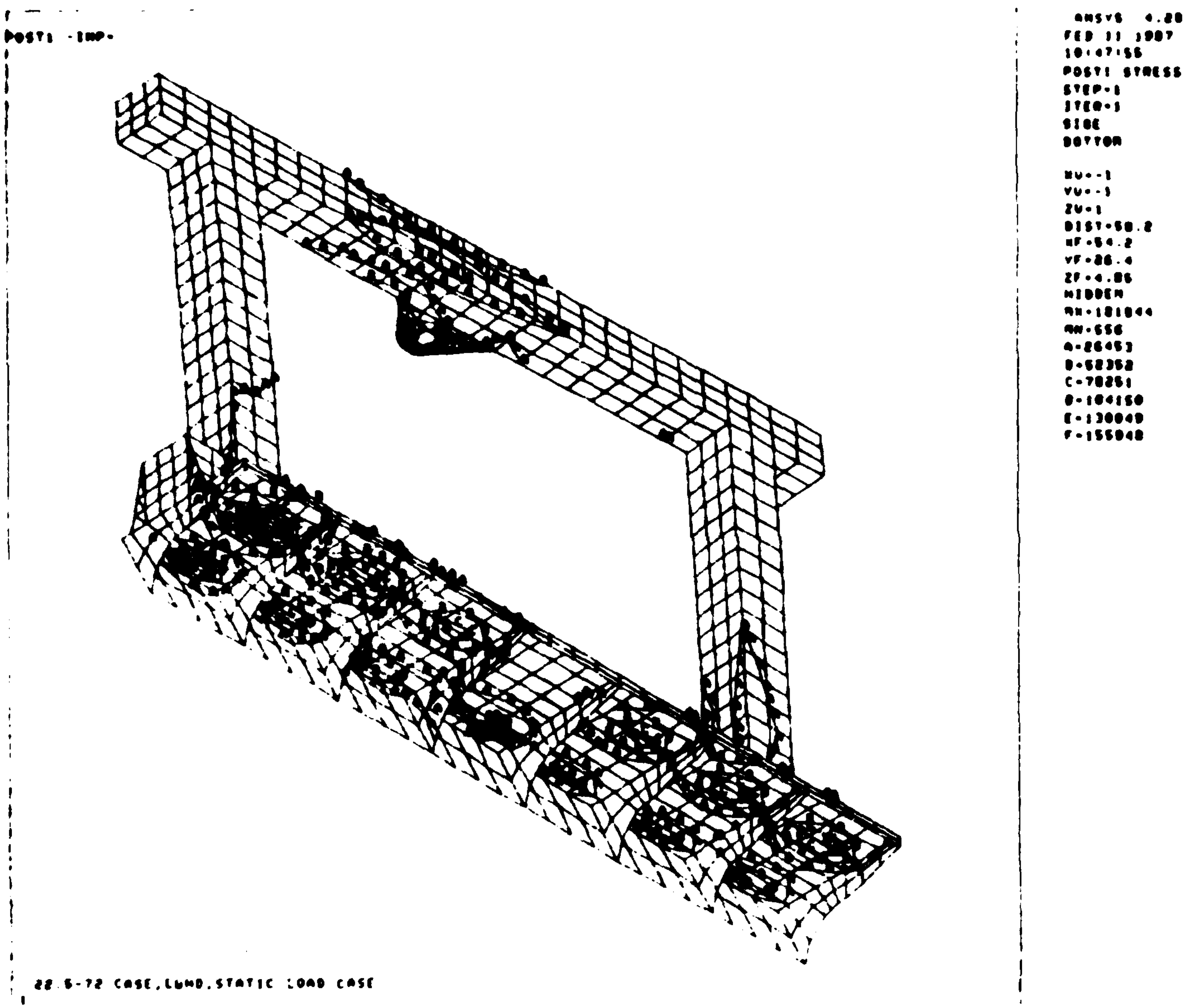
C. R. Ortloff

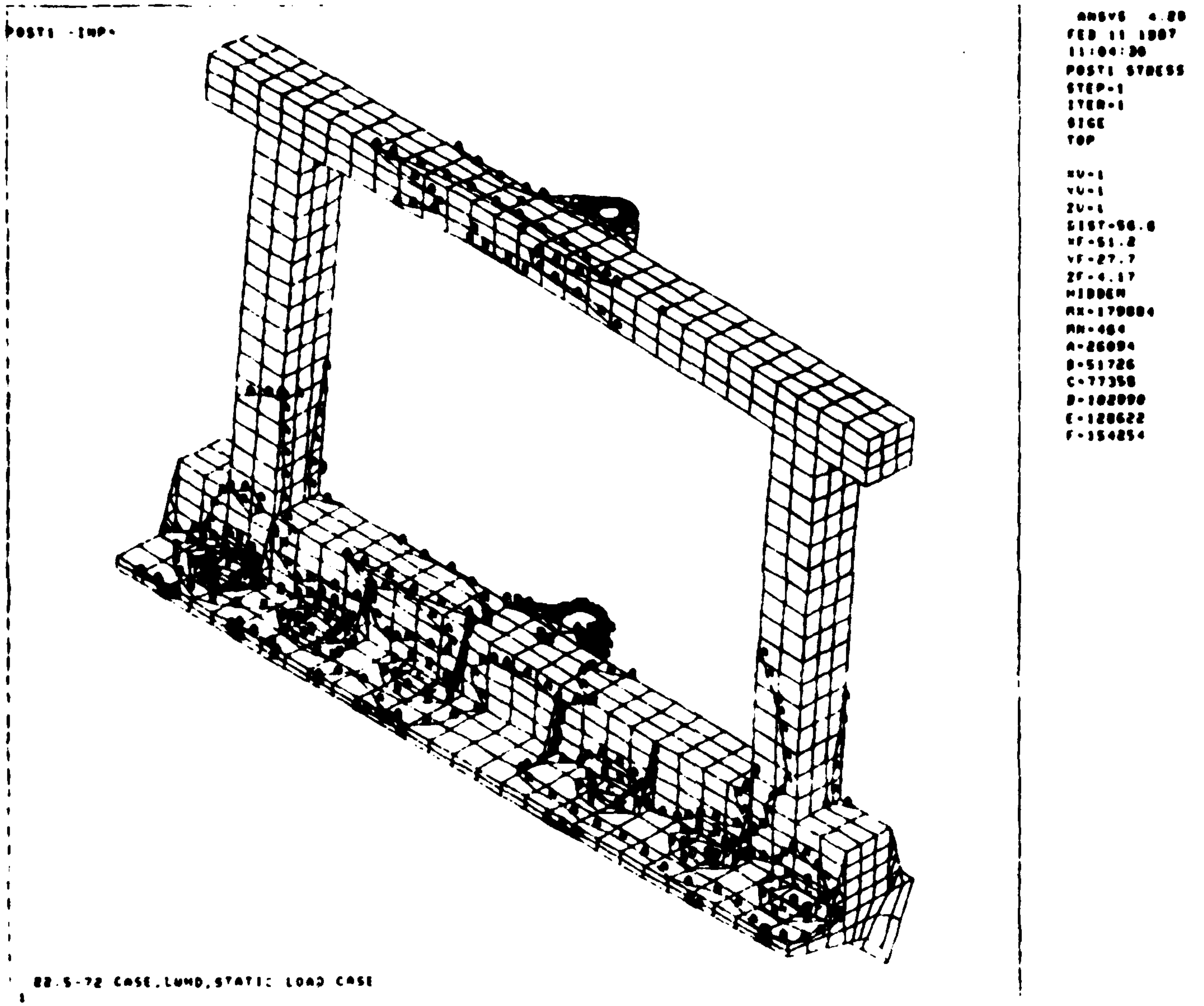


ANSYS
FEB 11 1987
POST1 STRESS
STEP=1
ITER=1
SIDE
TOP
XV=-1
YV=-1
ZV=1
HIDDEN
STATIC LOAD CASE

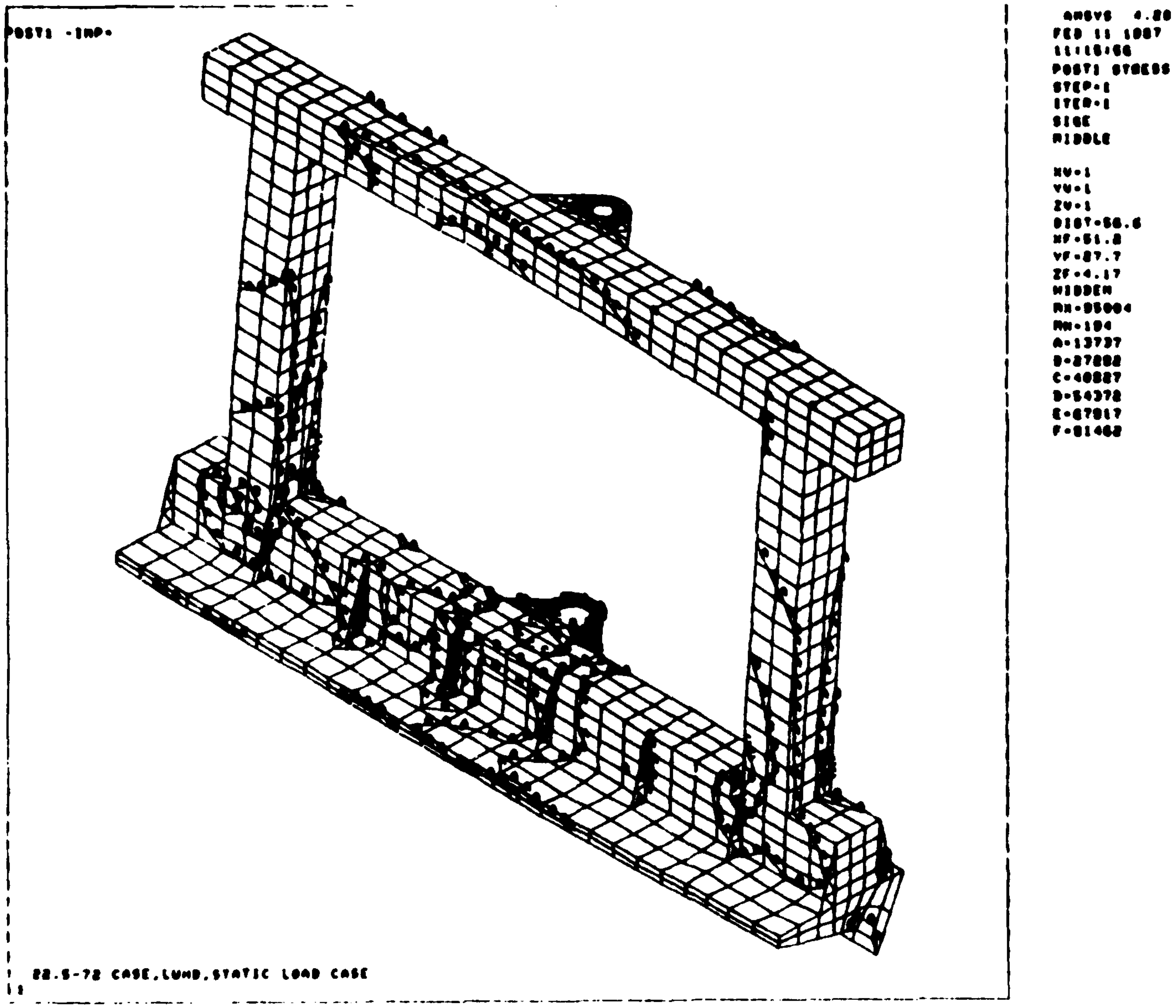


603

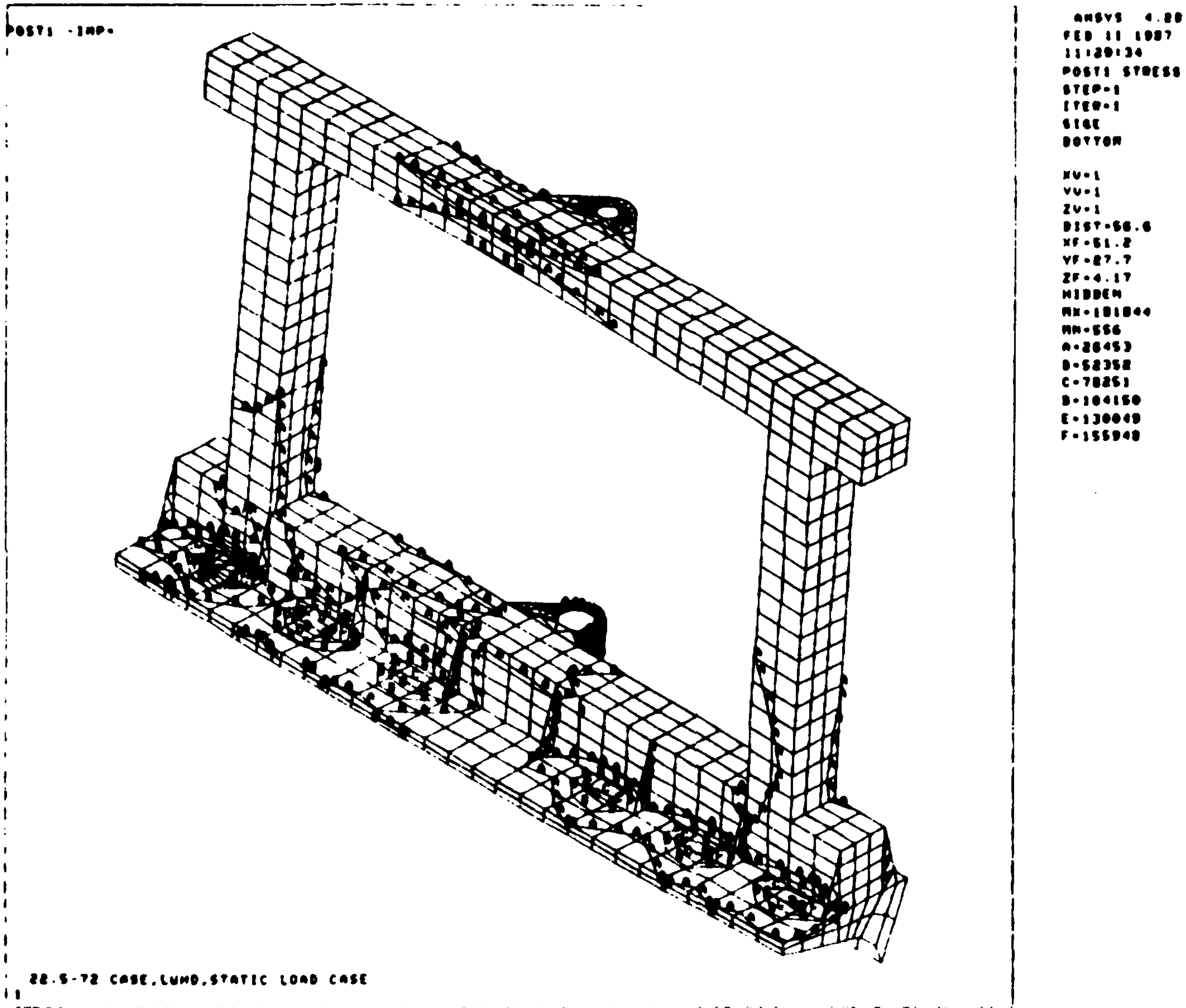

POST1 -INP-
ANSYS 4.2B
FEB 11 1987
10:47:55
POST1 STRESS
STEP=1
ITER=1
SIGE
BOTTOM
XV=-1
YV=-1
ZV=1
DIST=58.2
XF=54.2
YF=86.4
ZF=4.86
HIDDEN
MX=181844
MN=556
A=26453
B=52352
C=78251
D=104150
E=130049
F=155948
22.5-72 CASE, LUND, STATIC LOAD CASE


POST1 -INP-
ANSYS 4.2B
FEB 11 1987
11:04:30
POST1 STRESS
STEP=1
ITER=1
SIGE
TOP
XV=1
YV=1
ZV=1
DIST=56.6
XF=51.2
YF=27.7
ZF=4.17
HIDDEN
MX=179884
MN=464
A=26094
B=51726
C=77358
D=102990
E=128622
F=154254
82.5-72 CASE,LUMD,STATIC LOAD CASE

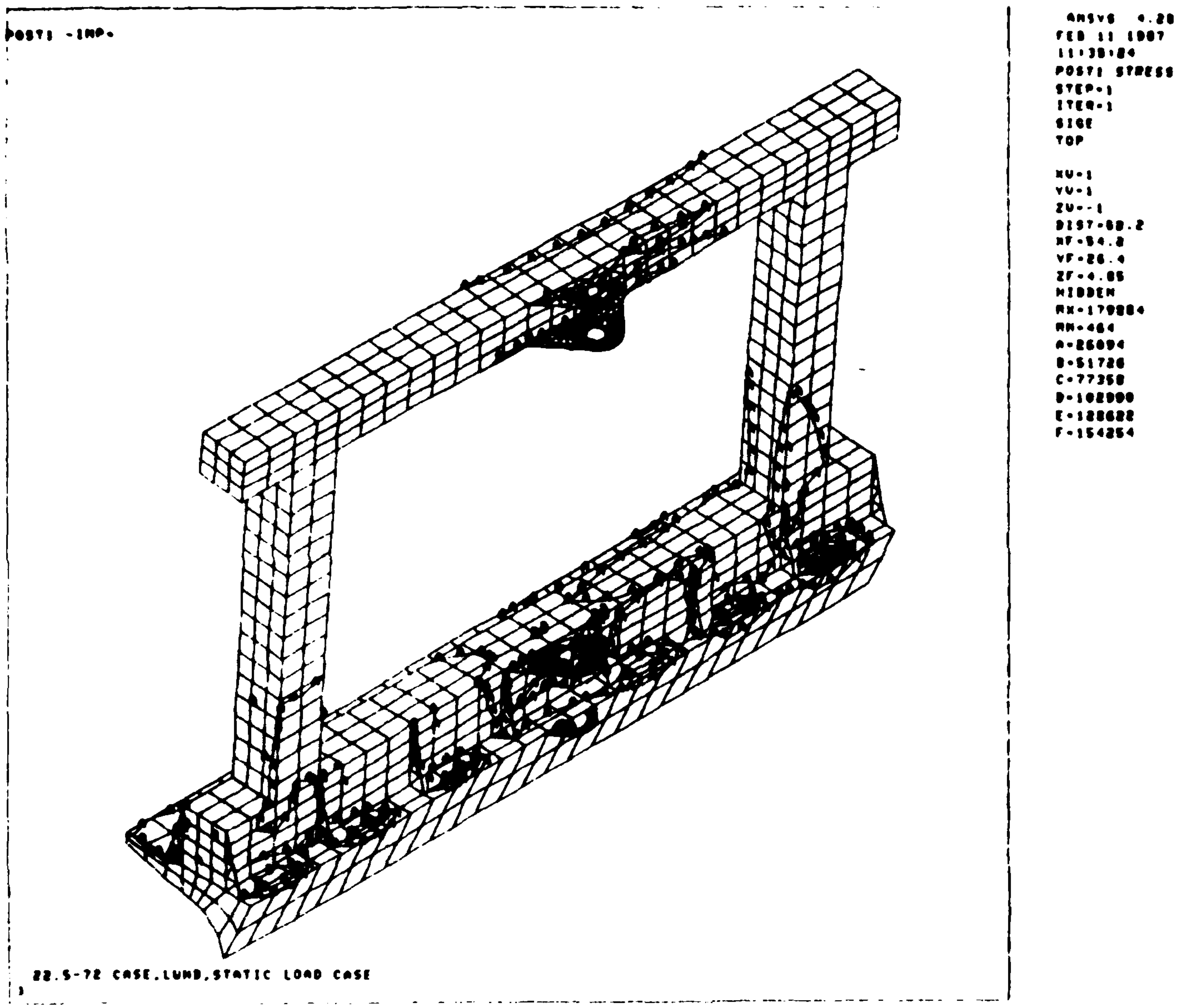
605

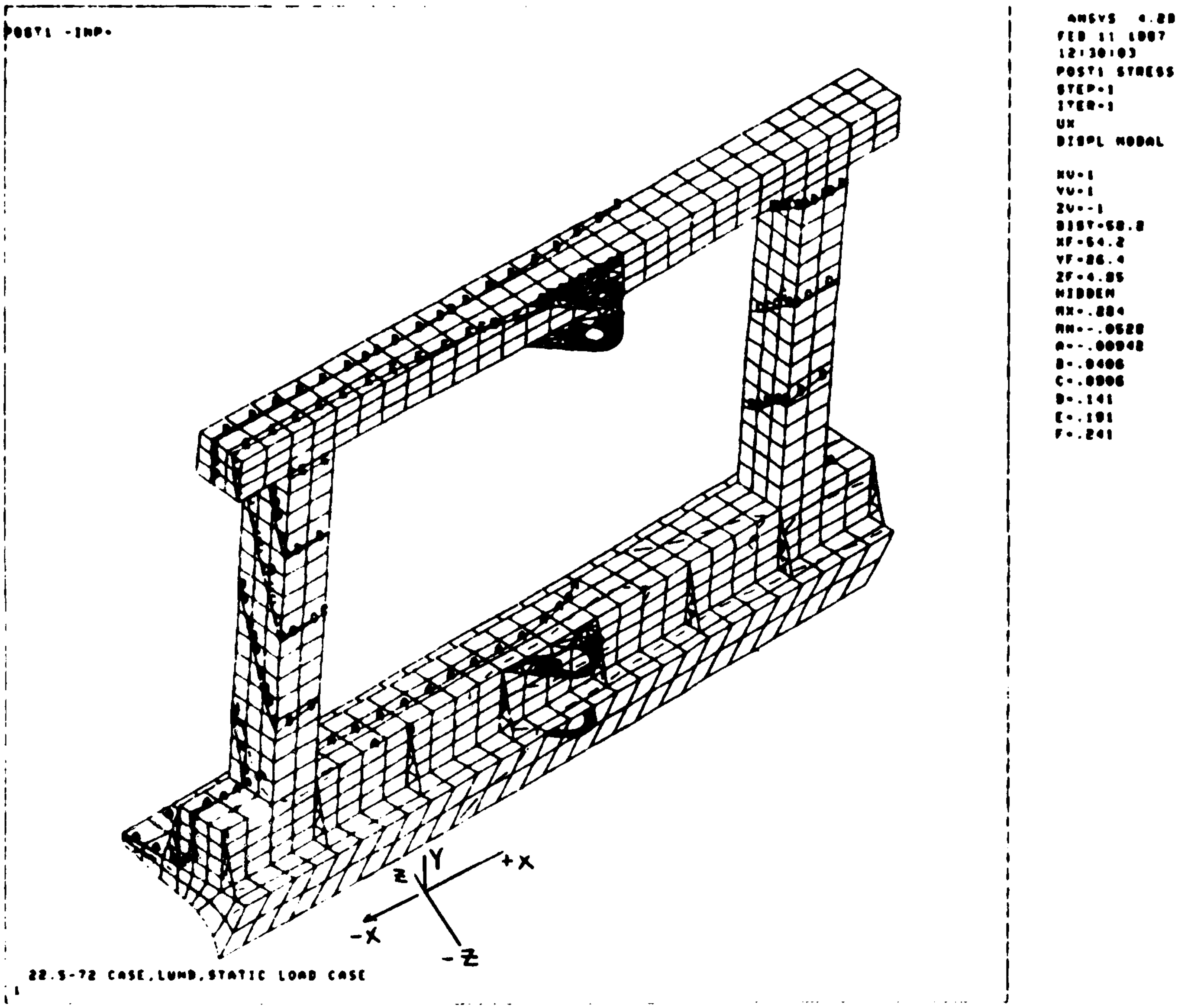

POST1 -INP-
ANSYS 4.2B
FEB 11 1987
11:15:56
POST1 STRESS
STEP=1
ITER=1
SIGE
MIDDLE
XV=1
YV=1
ZV=1
DIST=56.6
XF=51.8
YF=27.7
ZF=4.17
HIDDEN
MX=95004
MN=194
A=13737
B=27282
C=40827
D=54372
E=67917
F=81462
22.5-72 CASE,LUMP,STATIC LOAD CASE
1

606

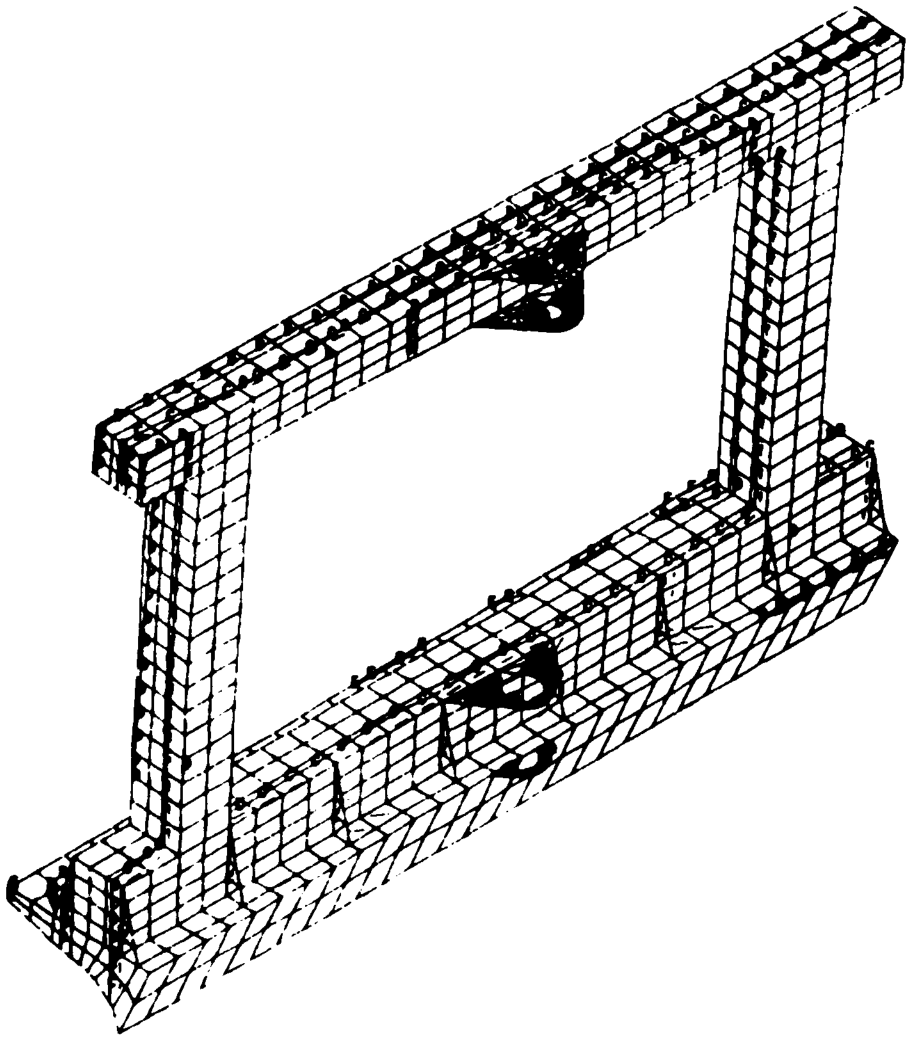

POST1 -IMP-
22.5-72 CASE,LUHD,STATIC LOAD CASE
ANSYS 4.2B
FEB 11 1987
11:20:34
POST1 STRESS
STEP=1
ITER=1
SIGE
BOTTOM
XV=1
YV=1
ZV=1
DIST=56.6
XF=51.2
YF=27.7
ZF=4.17
HIDDEN
MX=181844
MN=556
A=26453
B=52352
C=78251
D=104150
E=130049
F=155948

607


POST1 -INP-
ANSYS 4.2B
FEB 11 1987
11:38:84
POST1 STRESS
STEP=1
ITER=1
SIGE
TOP
XV=1
YV=1
ZV=-1
DIST=88.2
XF=54.8
YF=26.4
ZF=4.85
HIDDEN
MX=179884
MN=464
A=26094
B=51726
C=77358
D=102990
E=128622
F=154254
22.5-72 CASE,LUMB,STATIC LOAD CASE


POST1 -INP-
ANSYS 4.2B
FEB 11 1987
12:30:03
POST1 STRESS
STEP=1
ITER=1
UX
DISPL NODAL
XV=1
YV=1
ZV=-1
DIST=58.8
XF=54.2
YF=26.4
ZF=4.85
HIDDEN
MX=.284
MN=-.0528
A=-.00948
B=.0406
C=.0906
D=.141
E=.191
F=.241
Z
Y
+X
-X
-Z
22.5-72 CASE,LUMD,STATIC LOAD CASE

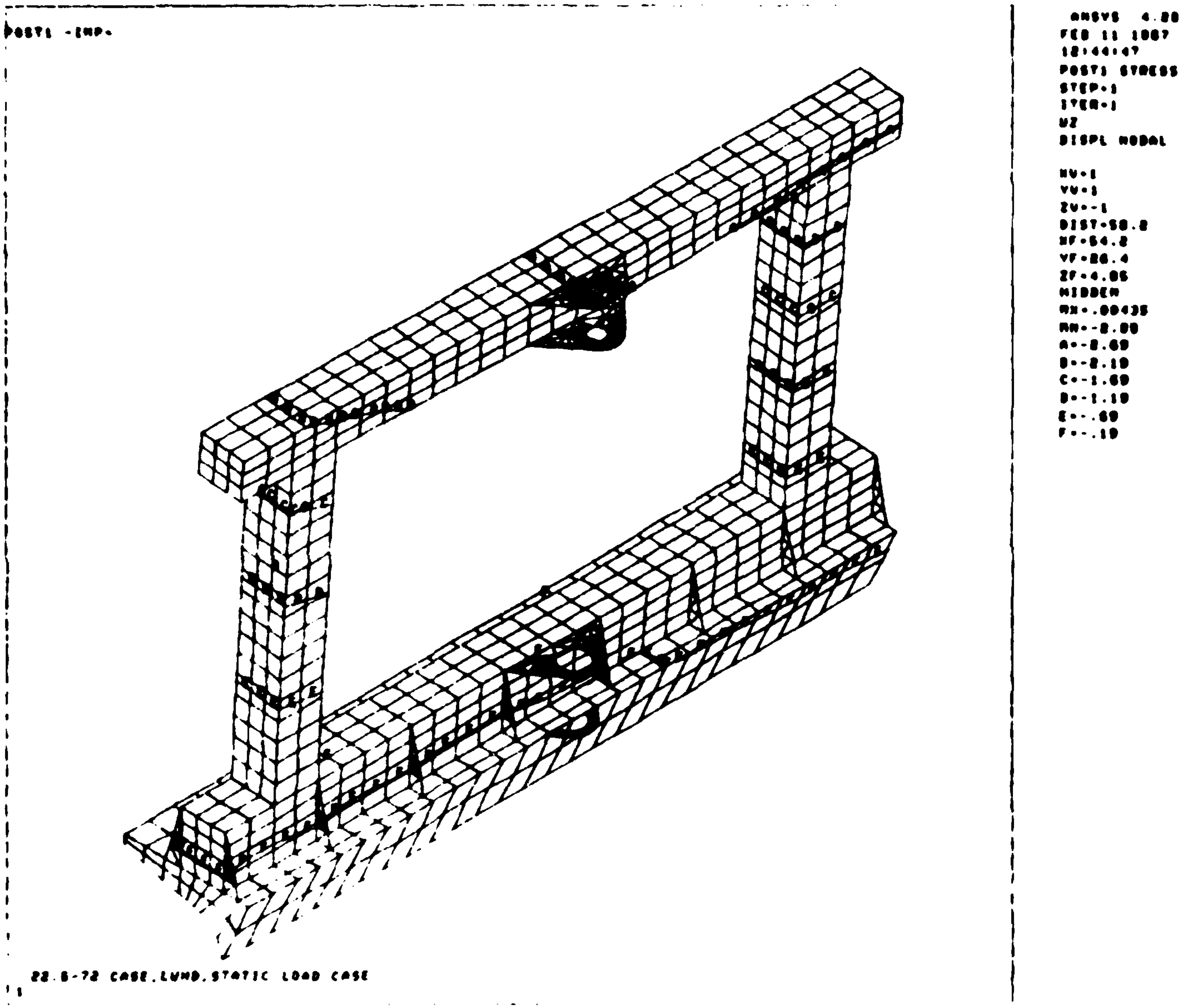
POST1 -INP-

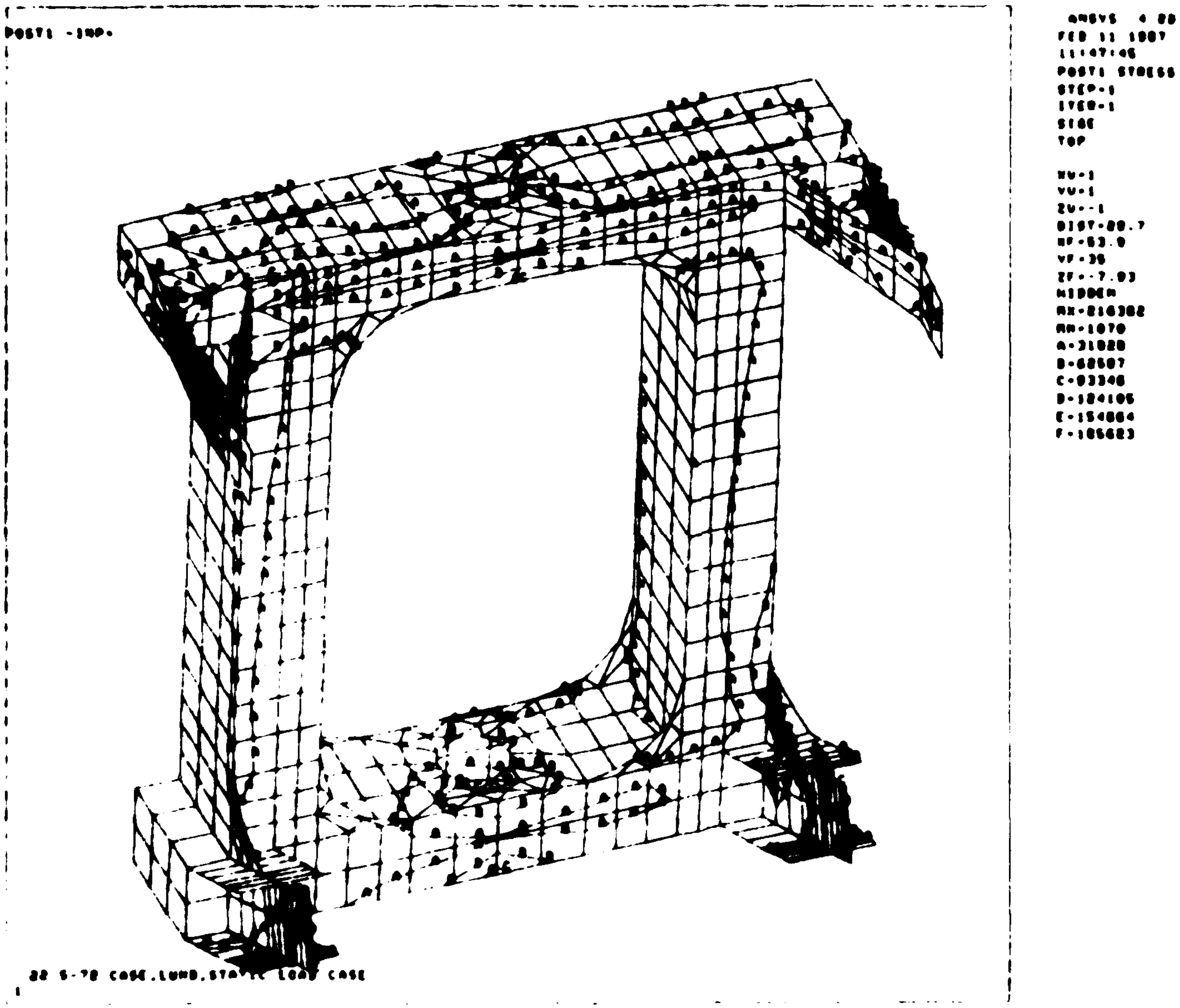


82.5-72 CASE, LUND, STATIC LOAD CASE

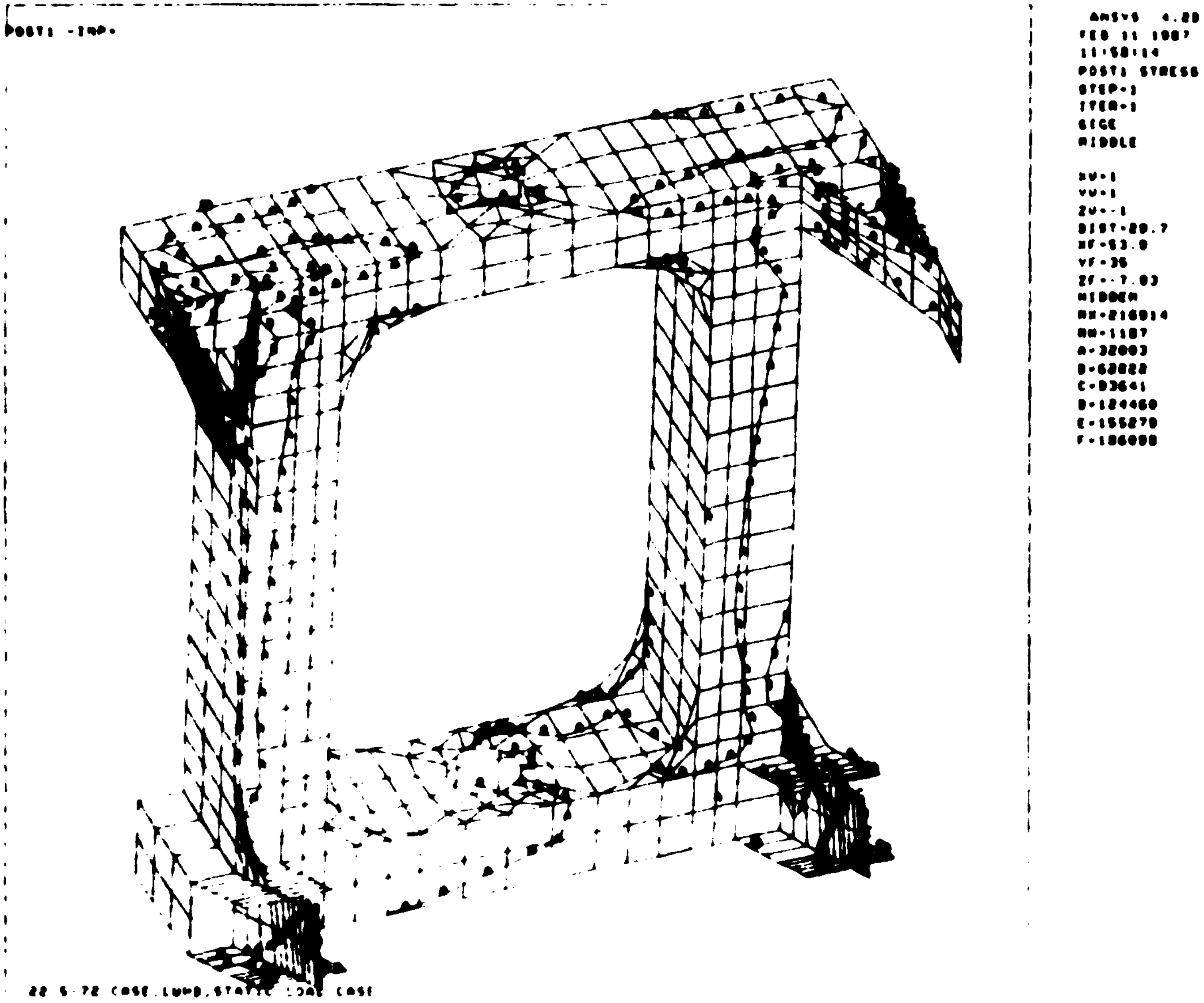
ANSYS 4.2B
FEB 11 1987
12:37:57
POST1 STRESS
STEP=1
ITER=1
UY
DISPL NODAL

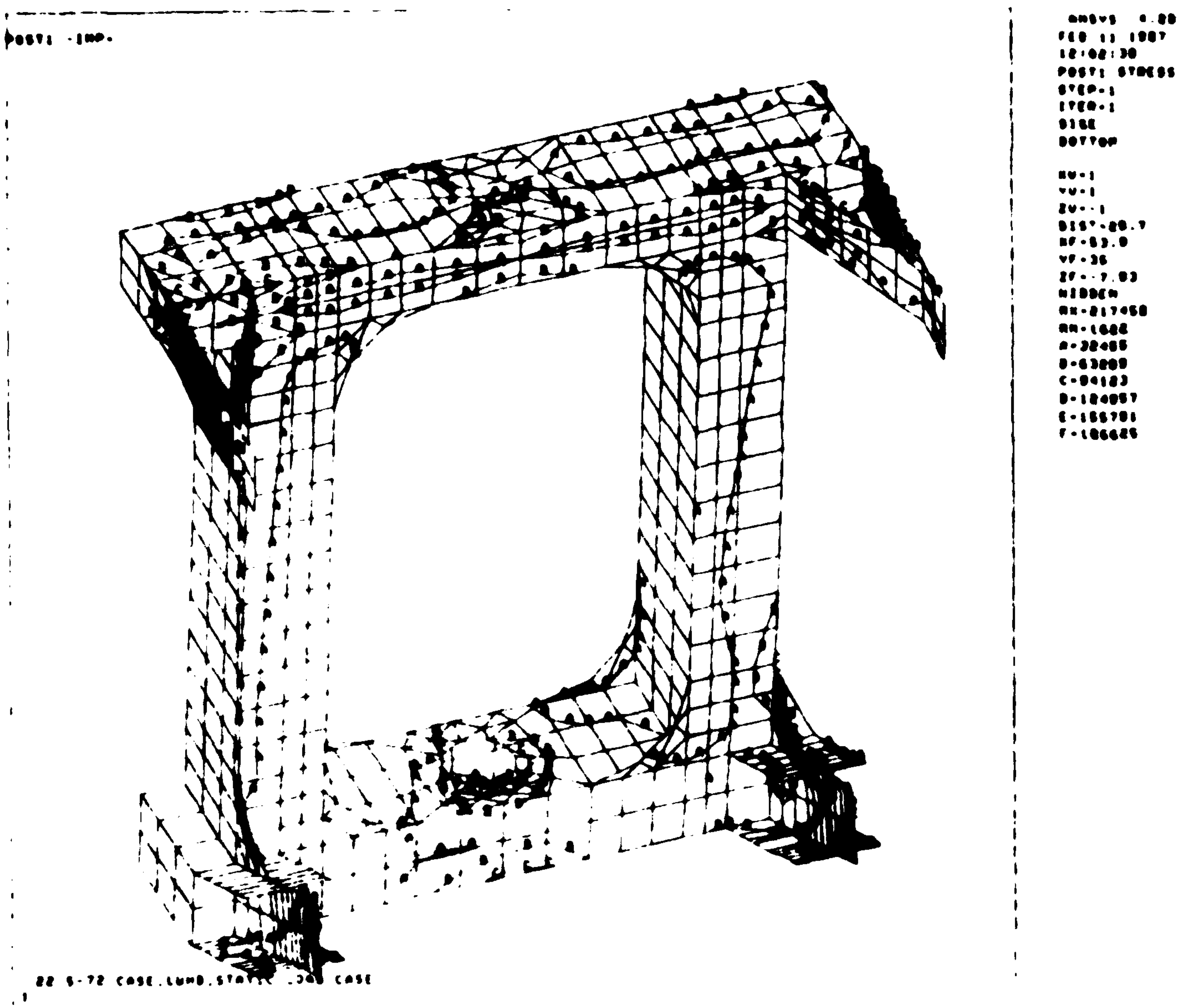
XV=1
YV=1
ZV=-1
DIST=58.8
XF=54.2
YF=26.4
ZF=4.05
HIDDEN
MX=.474
MN=-.308
A=-.217
B=-.0071
C=.0289
D=.143
E=.263
F=.383

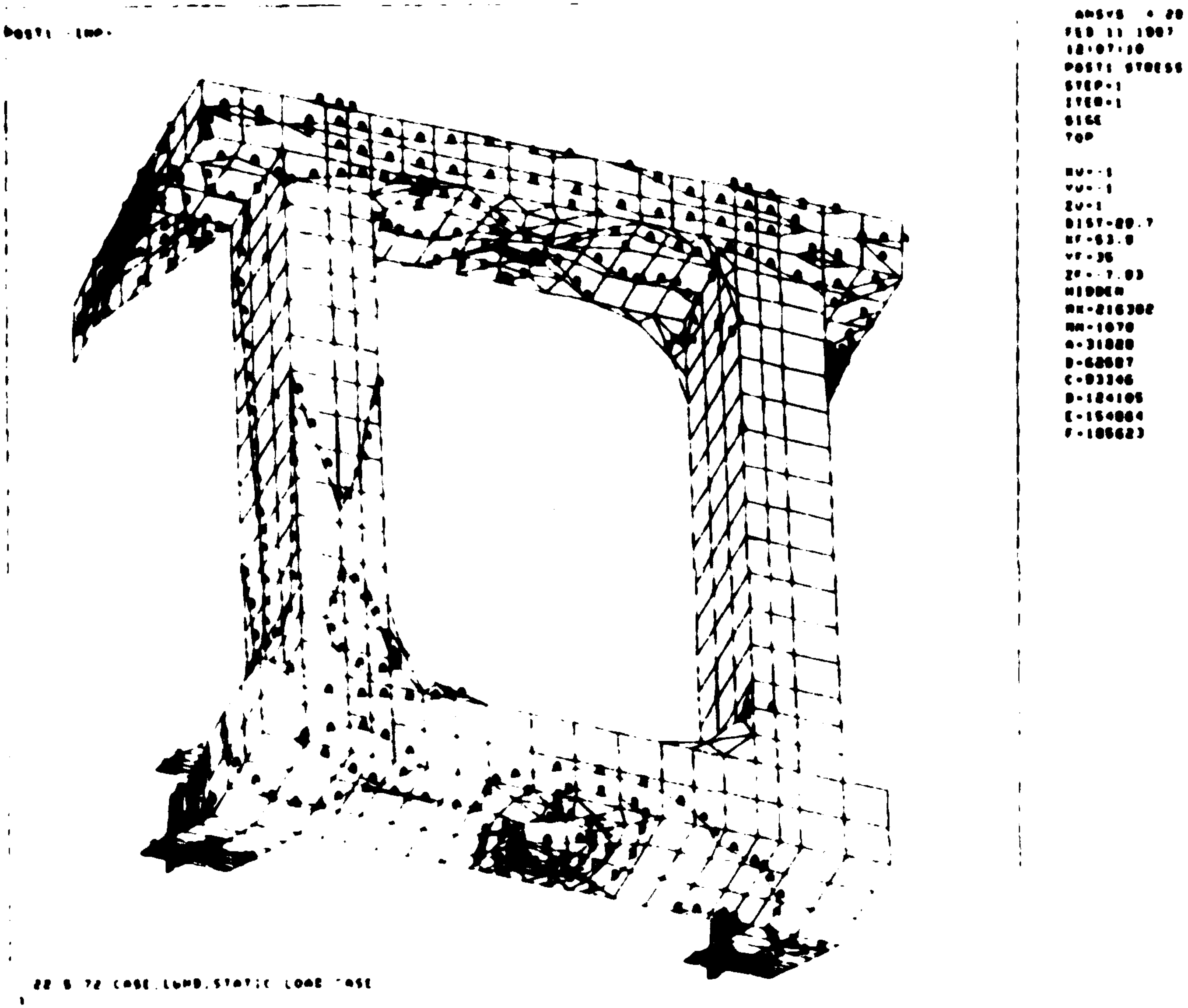

POST1 -INP-
ANSYS 4.2B
FEB 11 1987
12:44:47
POST1 STRESS
STEP=1
ITER=1
UZ
DISPL NODAL
XV=1
YV=1
ZV=-1
DIST=58.8
XF=54.2
YF=26.4
ZF=4.05
HIDDEN
MX=.00435
MN=-2.90
A=-2.69
B=-2.19
C=-1.69
D=-1.19
E=-.69
F=-.19
22.5-72 CASE.LUMD.STATIC LOAD CASE


POST1 -INP-
ANSYS 4.2B
FEB 11 1987
11:47:46
POST1 STRESS
STEP=1
ITER=1
SIDE
TOP
XV=1
YV=1
ZV=-1
DIST=88.7
XF=53.9
YF=36
ZF=-7.03
HIDDEN
MX=216382
MN=1070
A=31828
B=62587
C=93346
D=124105
E=154864
F=185623
22 S-78 CASE.LUMD.STATIC LOAD CASE

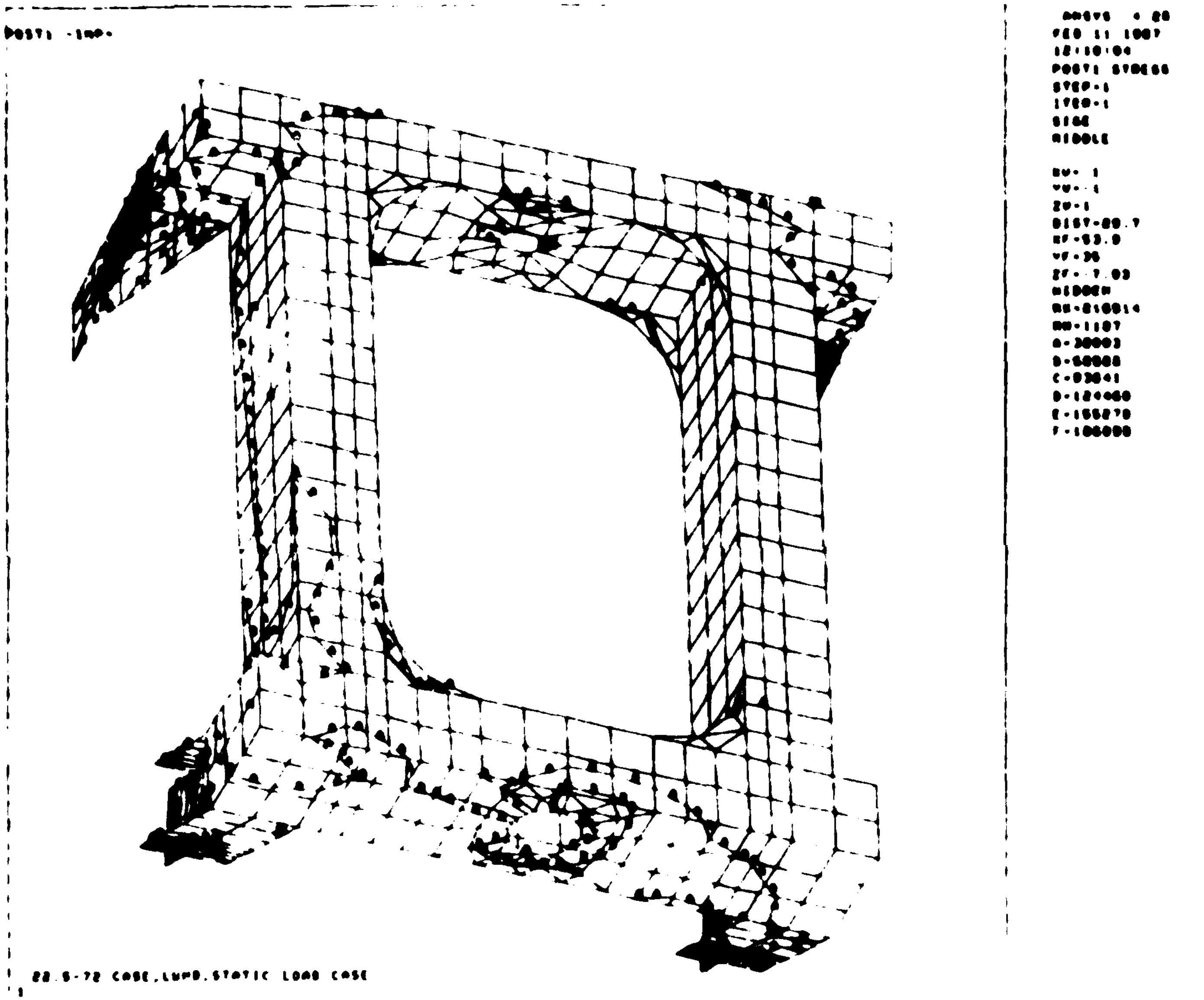
612

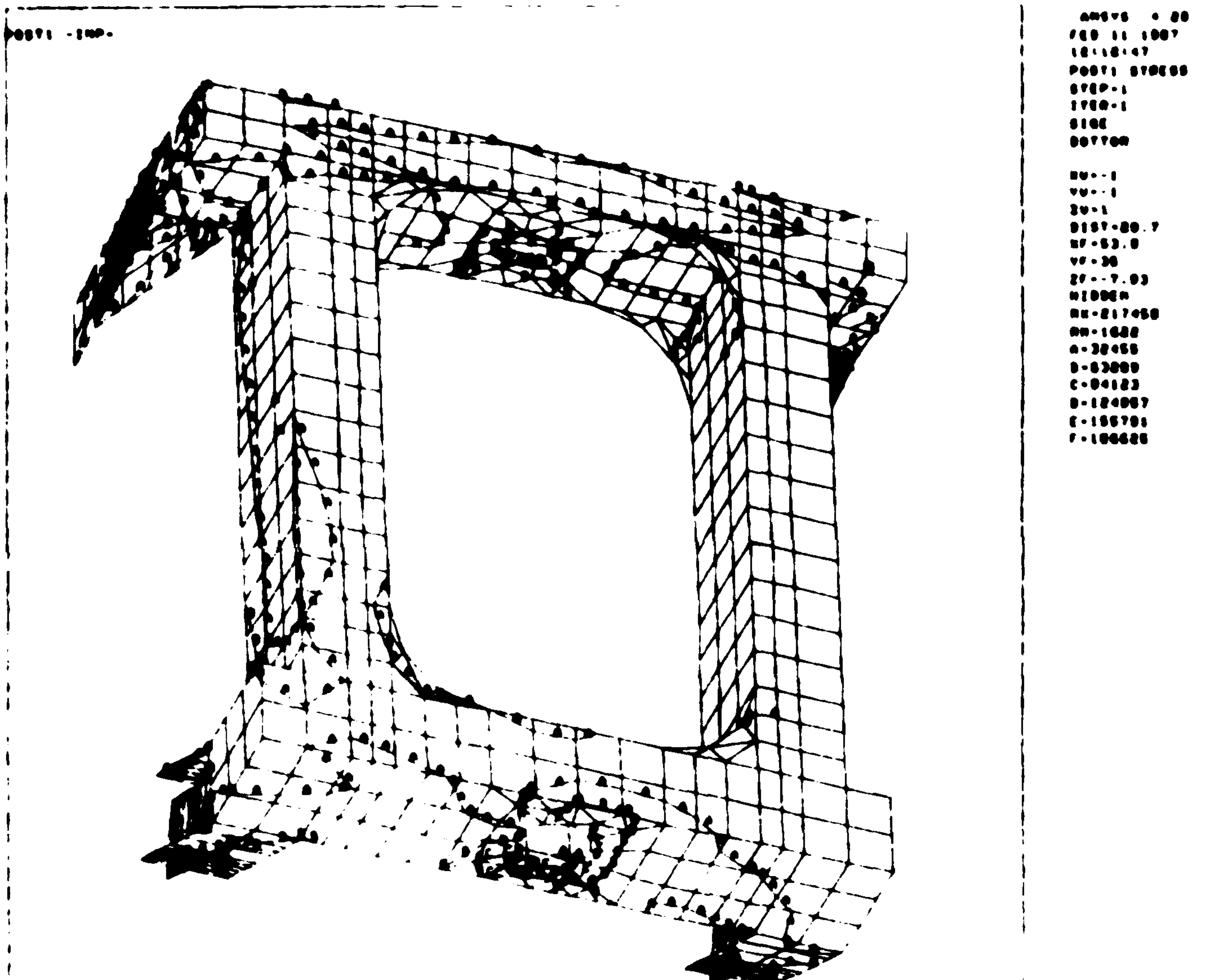

POST1 -INP-
ANSYS 4.2B
FEB 11 1987
11:58:14
POST1 STRESS
STEP=1
ITER=1
SIGE
MIDDLE
XV=1
YV=1
ZV=-1
DIST=29.7
XF=53.8
YF=36
ZF=-7.83
HIDDEN
MX=216914
MN=1187
A=32003
B=62822
C=93641
D=124460
E=155279
F=186098
22 S-72 CASE LUMP STATIC LOAD CASE


POST1 -IMP-
ANSYS 4.2B
FEB 11 1987
12:02:30
POST1 STRESS
STEP=1
ITER=1
SIGE
BOTTOM
XV=1
YV=1
ZV=-1
DIST=20.7
XF=53.0
YF=36
ZF=-7.03
HIDDEN
MX=217458
MN=1622
A=32455
B=63289
C=94123
D=124957
E=155791
F=186625
22 5-72 CASE.LUMB.STATIC .30 CASE

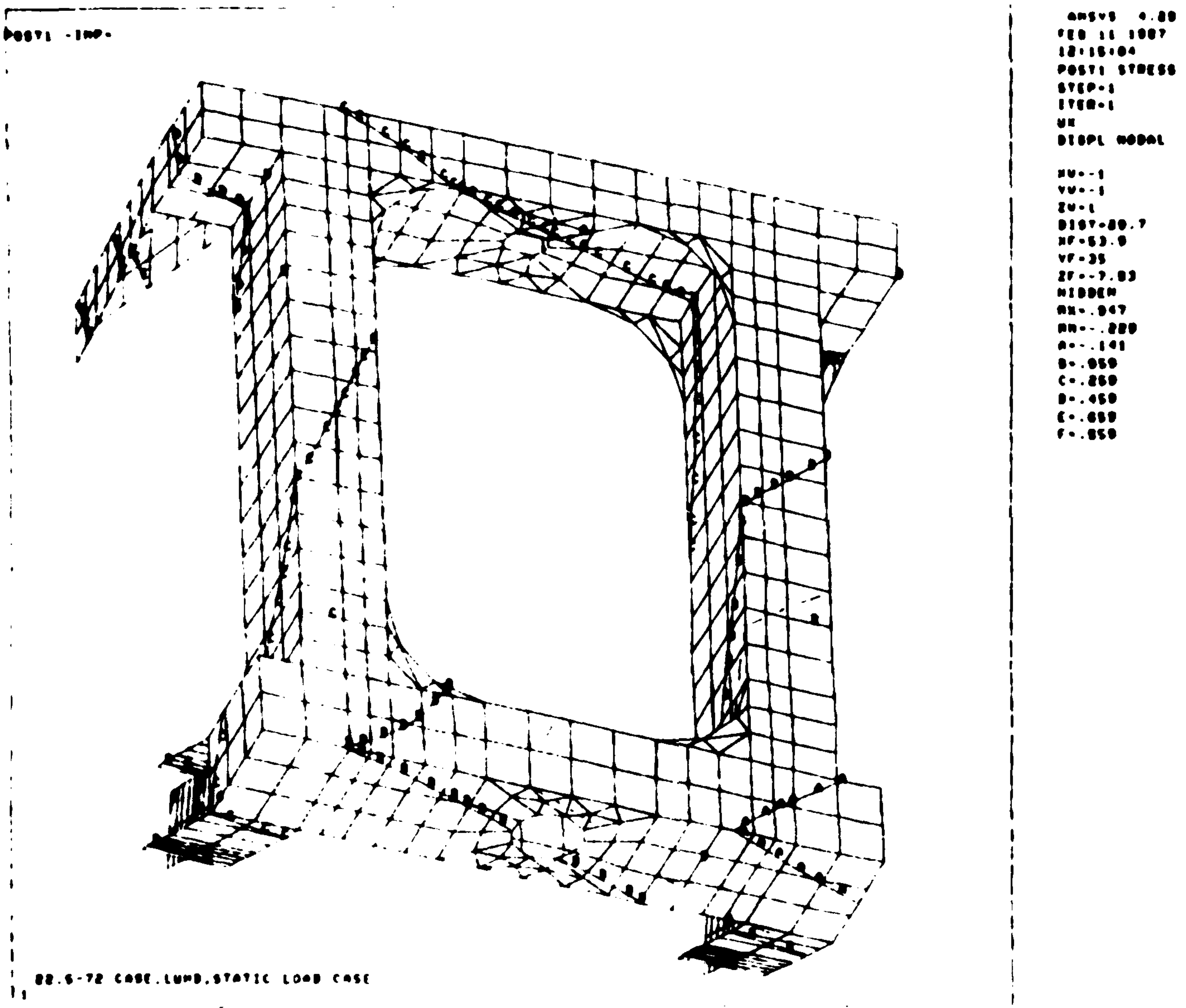

ANSYS 4.2B
FEB 11 1987
12:07:10
POST1 STRESS
STEP=1
ITER=1
SIGE
TOP
XV=-1
YV=-1
ZV=1
HIDDEN
D=124105
E=154864
F=185623

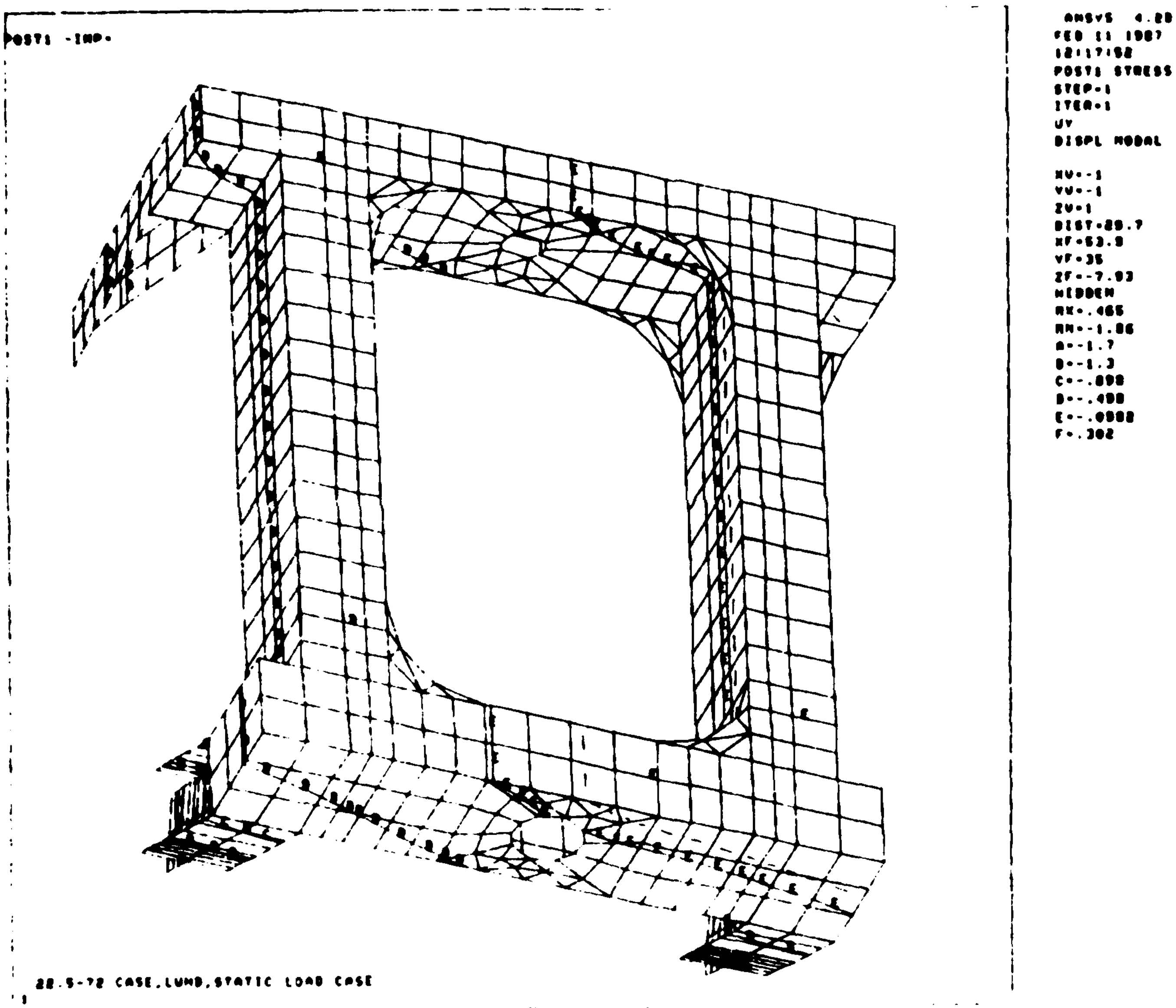
615


POST1 -INP-
ANSYS 4.2B
FEB 11 1987
12:10:04
POST1 STRESS
STEP=1
ITER=1
SIGE
MIDDLE
XV=1
YV=-1
ZV=1
DIST=89.7
XF=53.9
YF=36
ZF=-7.03
HIDDEN
MX=210014
MN=1107
A=30003
B=58888
C=83041
D=124460
E=155270
F=186000
22.5-72 CASE,LUMP,STATIC LOAD CASE

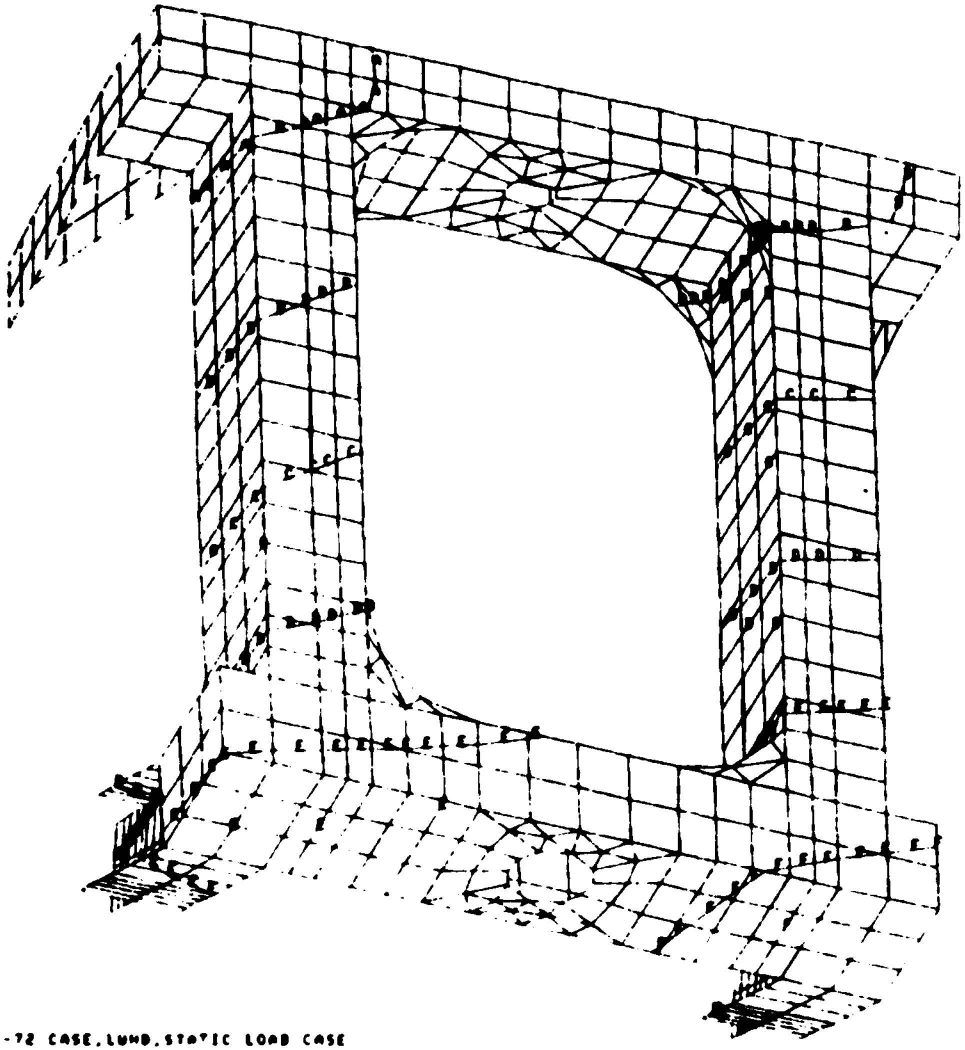


88.5-72 CASE.LWB.STATIC LOAD CASE


POST1 -INP-
ANSYS 4.20
FEB 11 1987
12:15:04
POST1 STRESS
STEP=1
ITER=1
UX
DISPL NODAL
XV=-1
YV=-1
ZV=1
DIST=80.7
XF=53.9
YF=35
ZF=-7.83
HIDDEN
MX=.947
MN=-.280
A=-.141
B=.050
C=.250
D=.450
E=.650
F=.850
82.5-72 CASE.LUMB.STATIC LOAD CASE


POST1 -INP-
ANSYS 4.2B
FEB 11 1987
12:17:52
POST1 STRESS
STEP=1
ITER=1
UY
DISPL MODAL
XV=-1
YV=-1
ZV=1
DIST=29.7
XF=53.9
YF=35
ZF=-7.93
HIDDEN
MX=.465
MN=-1.86
A=-1.7
B=-1.3
C=-.898
D=-.498
E=-.0982
F=.302
22.5-72 CASE,LUMP,STATIC LOAD CASE

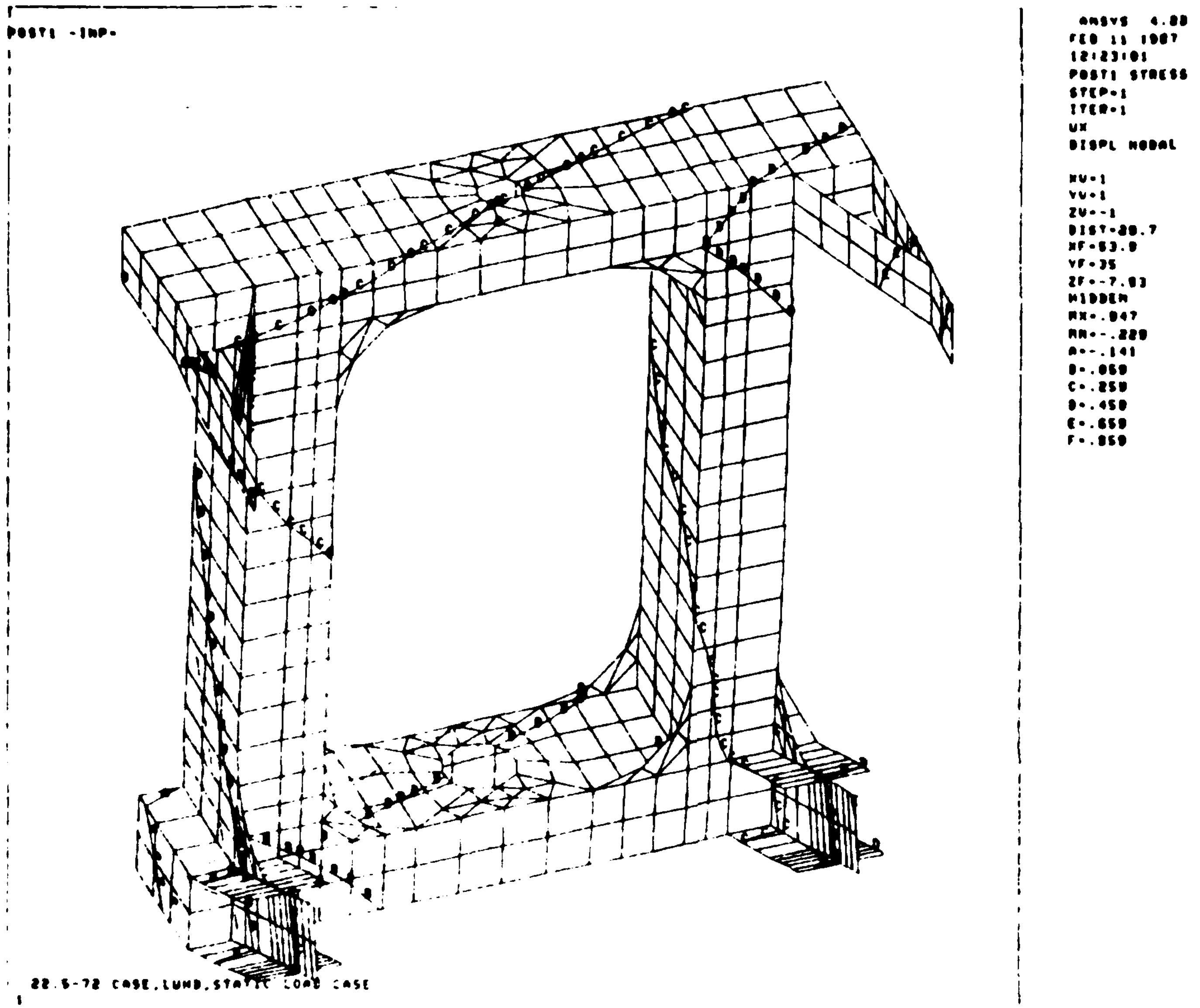
POST1 -INP-

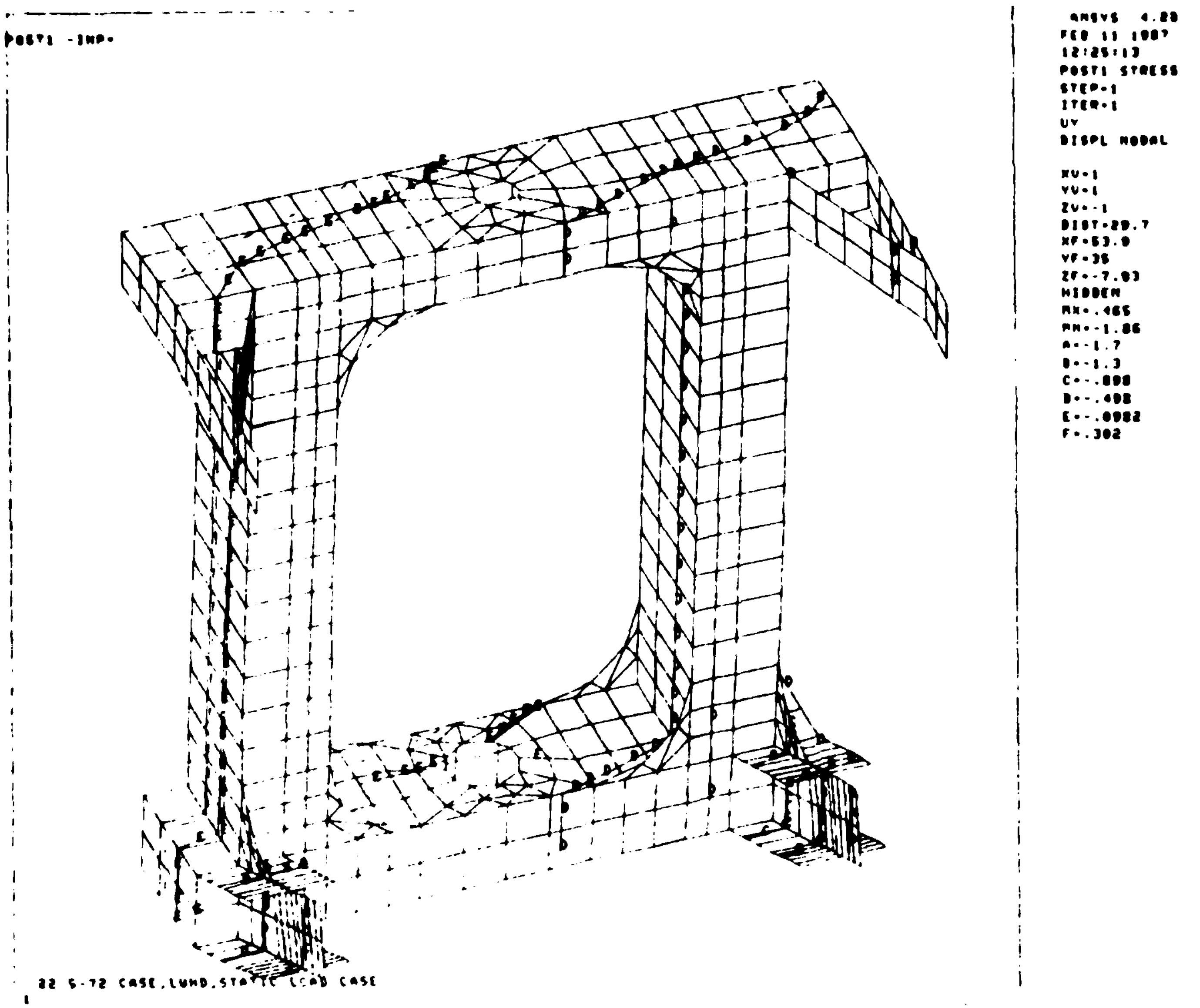


ANSYS 4.2B
FEB 11 1987
12:20:25
POST1 STRESS
STEP=1
ITER=1
UZ
DISPL NODAL

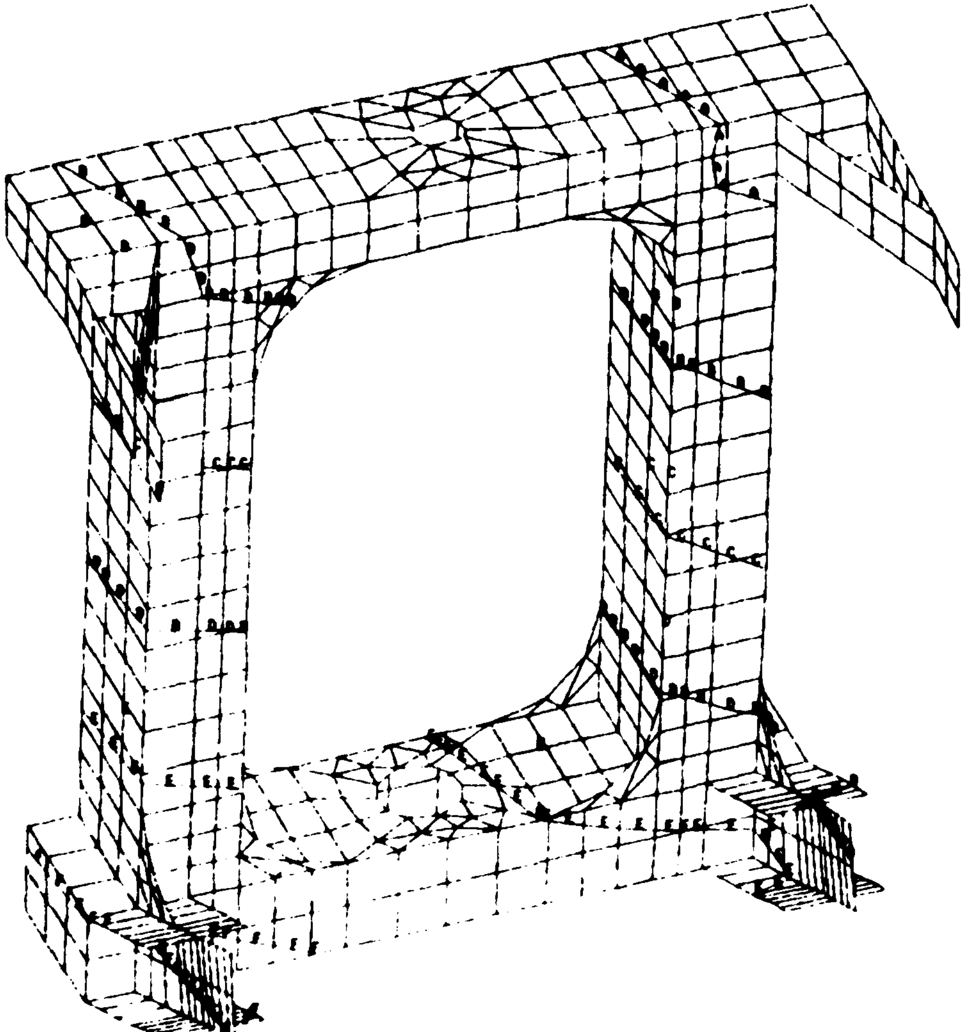
XV=-1
YV=-1
ZV=1
DIST=29.7
XF=53.9
YF=35
ZF=-7.93
HIDDEN
MX=-.0178
MN=-3.11
A=-2.82
B=-2.32
C=-1.82
D=-1.32
E=-.815
F=-.315

22.5-72 CASE,LUMD,STATIC LOAD CASE


POST1 -INP-
ANSYS 4.2B
FEB 11 1987
12:23:01
POST1 STRESS
STEP=1
ITER=1
UX
DISPL NODAL
XV=1
YV=1
ZV=-1
DIST=28.7
XF=53.9
YF=35
ZF=-7.93
HIDDEN
MX=.047
MN=-.220
A=-.141
B=.059
C=.259
D=.459
E=.659
F=.859
22.5-72 CASE,LUMB,STATIC LOAD CASE


POST1 -INP-
ANSYS 4.2B
FEB 11 1987
12:25:13
POST1 STRESS
STEP=1
ITER=1
UY
DISPL NODAL
XV=1
YV=1
ZV=-1
DIST=29.7
XF=53.9
YF=35
ZF=-7.03
HIDDEN
MX=.465
MN=-1.86
A=-1.7
B=-1.3
C=-.898
D=-.498
E=-.0982
F=.302
22 S-72 CASE,LUHD,STATIC LOAD CASE

POST1 -INP-



28.5-72 CASE.LUMP.STATIC LOAD CASE

END

10-87

DTIC